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ABSTRACT

This manual provides information needed to meet specific standards for certification as a pesticide applicator. Each of the eight chapters deals with a different aspect of pesticide use. Chapter one discusses the problems of use, particularly those associated with safety. Chapter two is concerned with the identification and diagnosis of insects and disease while the third chapter discusses a variety of equipment types and their utilization. The remaining chapters deal with pests of the specific categories of vegetables, field and forage crops, trees, fruits and vines, Christmas trees, and agricultural crops. (CS)

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SUBCATEGORY PLANT

SE 024 074

INSTRUCTIONS FOR USING THIS TRAINING MANUAL

This training manual is intended to provide you with the information you will need to meet the standards of the U. S. Environmental Protection Agency for commercial certification as a pesticide applicator in the subcategory Agricultural - Plant, and to prepare you to take an examination given by the pesticide regulatory agency based on this manual. It is not intended that this manual or training will provide you with all the information that you need for effective pest control. Up-to-date information regarding recommended materials and methods should be obtained from your Cooperative Extension office, your state extension publications and the label.

The manual is designed for use as a self-study manual by individuals, or it may be used in conjunction with other training materials at training schools. Your core manual (either the Northeast or EPA-USDA core training manual) is the basic information manual for all pesticide applicators. This manual begins where the core manual left off. Refer back to your core manual as necessary.

This manual was developed to be used in an open book exam since it contains resource information that is not intended for memorization. It will require careful study so that you are sufficiently familiar with its contents that needed information can be quickly found and used within the period allowed for examination.

You should place this manual in the same binder with your Northeast Core Manual or with the core manual you used for certification at the core level to qualify you for category certification.

PESTICIDE APPLICATOR TRAINING MANUAL
CATEGORY 1
AGRICULTURAL

SUBCATEGORY - PLANT

A Training Program for the Certification
of Commercial Pesticide Applicators

Cooperative Extension
Chemicals-Pesticides Program
New York State College of Agriculture and Life Sciences
at
Cornell University, Ithaca, New York

January 1977

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INTRODUCTION

You have completed the core training of pesticide certification and now are about to start additional training for your commercial certification. This manual will cover information in the following commercial categories:

a) Agricultural (plant)
b) Forestry
c) Ornamentals and Turf

You will be responsible for the general information that appears in Chapters I, II,and III, along with the specific information that pertains to your category training, but not for all the information presented. For example, if you are a turf manager, you would not be expected to know the pests associated with tree fruit, or vegetables, or how to calibrate orchard airblast equipment.

The purpose of this manual is to:

-- provide federal minimum category standards for certification
-- provide identity to some common problems in the use of pesticides
-- provide identity to some common pests
-- provide methods of calibration, maintenance and operations of equipment used in the application of pesticides in agriculture

This manual focuses on principles which apply to your operations and which will enable you to improve your competency to use pesticides.

Standards for Certification

The Environmental Protection Agency has set minimum standards for certification of pesticide applicators. Among these standards is a section relating to your operations as a commercial applicator.

The specific standards from the Federal Register for this category of commercial applicators are as follows:

> "Applicators must demonstrate practical knowledge of crops on which they may be using restricted use pesticides (non-restricted as well in New York State). The importance of such competency is amplified by the extensive areas involved, the quantities of

pesticides needed, and the ultimate use of many commodities of food and feed. Practical knowledge is required concerning soil and water problems, preharvest intervals, reentry intervals, phytotoxicity, and potential for environmental contamination, non-target injury and community problems resulting from the use of restricted use pesticides in agricultural areas".

You will need specific information for your local situation. Cooperative Extension and your industry organization are sources for such information.

Responsiblity for Certification

It is the Environmental Protection Agency's responsibility to see that minimum standards are met. A lead agency is designated in each state that is responsible to EPA for certification training and enforcement. The Department of Environmental Conservation is the lead agency for New York State. Within the agency the Bureau of Pesticides has all regulatory responsibilities dealing with pesticides, including preparing and giving the examinations for certification and enforcing the requirements.

Cooperative Extension is responsible for training pesticide applicators in preparation for certification. The core level of training for both private and commercial applicators is offered in individual counties through the local Cooperative Extension field staff. Category training is offered by teams of specialists (mainly from Cornell), usually on a regional basis. All examinations are administered by a representative of DEC.

Crops and Pests

Commercial applicators must demonstrate practical knowledge of crops grown and the specific pests of these crops on which they may be using restricted use pesticides.

Your full and adequate knowledge of crops and pests for which you provide service is basic to performance of your work. You must:

-- accurately identify the pests
-- apply the most effective and efficient control measures
-- determine the necessity of chemical control
-- select the correct registered pesticides

With this knowledge, your ability to provide safe and effective service to your customers or employer will be greater.

Concern for Others

Practical knowledge is required to recognize:

-- soil and water problems - leaching, residues, erosion, etc.
-- the potential for contamination of water by your pesticide application
-- preharvest intervals and reentry intervals.

   Preharvest intervals and reentry intervals are established to protect the consumer from harmful residues and the safety of your workers. It is your responsibility to ensure that each customer is completely informed about these intervals.

-- phytotoxicity and potential for environmental contamination.

   Bad habits and sloppy practices can result in environmental contamination which can be avoided or reduced by careful supervision to maintain strict adherence to approved methods and label directions.

-- nontarget injury

   Areas adjacent to the target crop may receive pesticide drift. This can result in either harmful residues on food or feed crops or, in the case of some herbicides, may result in plant injury.

-- community problems (such as "in-line" housing, streams, ponds, or lakes, school grounds, etc.) resulting from the use of pesticides in agricultural areas.

Careless habits resulting in misuse, littering the landscape, and contamination of the environment are not only prohibited by law but also contribute to bad public relations.

Your concern for the environment including people who live, play, or work near your operations, is vital to your future.

I. PROBLEMS WITH PESTICIDE USE

Your core manual deals mostly with the acute hazards of pesticides to man and other warm blooded animals that are associated with handling of highly toxic pesticides. As a commercial applicator you are daily exposed to many pesticides ranging from low to high toxicity. You must consider their total effect on yourself, and such possible side effects as phytotoxicity, bee toxicity, drift damage, reentry, residues, tolerances, etc. Your health and repeat business depends on your knowledge and care in application.

Hazards to the Applicator, Worker and Consumer

Dermal Toxicity to the Applicator

You must not swallow, touch, or inhale pesticides. Your greatest hazard from pesticides is from skin contact which results in absorption through the skin. According to a survey in a leading agricultural state, absorption through the skin was responsible for over 80% of the cases of poisoning from agricultural and industrial use of agricultural chemicals. This can result from a splash, spill, or drift when you and/or your help are mixing or applying the chemical, or from contact with a pesticide "deposit" or "residue" after it has been applied.

The hazard of skin absorption is increased by cuts, abrasions, scratches, scuffs, or other damage to the skin. However, absorption can occur rapidly even through healthy skin. Absorption is high and rapid through the scrotum, arm pit, ear canal, forehead and scalp. It is lower and slower in the palm of the hand, or ball of the foot. However, even in these lower absorption areas, penetration can be great and vary from material to material. Carbaryl (Sevin) for example, is thought of as a relatively safe material, but is absorbed through the skin of the forearm about seven times more rapidly than malathion or parathion. Whether highly toxic or relatively safe, any pesticide spilled or splashed on the skin should be washed off immediately. Studies show that pesticides can be absorbed within a few minutes. Waiting until a job is done before washing may be too late! Wash by rubbing the hands together or with a piece of cloth using detergent or soap. Do not scrub with a brush since the outer protective layer of the skin may be scratched enough to allow more rapid absorption of any pesticide which is not removed. Hands should be protected with gloves when working on spray machinery.

Eyes

Eyes are particularly sensitive to harm by pesticides and should be protected with goggles or a face shield. If pesticide is splashed into the eye, immediately wash it with a gentle stream of clean running water while holding the eyelid open. A few seconds delay greatly increases the extent of injury. Large amounts of water should be used and continued for 15 minutes or more. Do not use chemicals or drugs in wash water. They may increase the injury. Convenient plastic eye wash bottles and holders are now available. These useful bottles can be purchased from chemical laboratory suppliers and are called "eye wash stations."

Lungs

Most applicators do not feel that inhalation of pesticides is a serious hazard. It is next in importance to skin contact as a cause of agricultural accidents. Because the lungs have such a large and highly absorptive surface area, even small amounts of pesticide are hazardous because they are almost completely absorbed. Vapors and extremely fine particles, 10 microns or smaller, are a particular hazard. Field tests in fruit orchards with airblast sprayers using eight times the normal dilute concentration have shown that the respiratory hazard is about three times greater than when operating with conventional dilute sprayers. Respirators should be worn as indicated on the pesticide label and whenever else that you think such protection is desirable. Occasional use of most moderately toxic pesticides does not usually require use of a respirator. Daily use of these pesticides, however, greatly increases your exposure and may necessitate use of a respirator. It is also wise to wear a respirator when using moderately toxic pesticides such as malathion during the same day or days that you are using highly toxic pesticides of the same family.

Respirators and Gas Masks for Pesticides

All respirators intended for use with pesticides must be approved jointly by the Mining Enforcement and Safety Administration (MESA) and the National Institute of Occupational Safety and Health (NIOSH). Approval numbers beginning with the letters TC are assigned to all respirators approved by the new agency. This number must be on the box containing the facepiece. Cartridges and filters approved for pesticides are necessary and must have the TC

number affixed to them plus the part number of the replacement part. Chemical cartridge respirators approved for pesticides will have the code number 23C following the letters TC and gas masks will have the number 14G following TC. Respirators having numbers other than TC numbers (i.e., BM numbers) are no longer approved unless they can be upgraded to meet requirements through the use of appropriate cartridges and filters.

As of April 1, 1976, it is our understanding that the following respirators are approved for pesticide use under the new standards:

Standard Chemical Cartridge Respirators

-- MSA number 459520 respirator with 459519 cartridge. Approval number TC-23C-45. Mine Safety Appliances Co.

-- Willson AGRI-TOX-2 respirator. 7200 series respirator with R21 Chemical Cartridges, R15 filters and R683 filter retainers. Approval Number TC-23C-54. Willson Products Division, ESB, Inc.

-- Welsh 7549 respirator with 7500-21 cartridges and 7500-23 filters. Approval number TC-23C-74. Welsh, A Textron Co.

-- MSA 448848 respirator with 448847 cartridges. Approval number TC-23C-79. Mine Safety Appliances Co.

-- AO number R5058 or R6058 respirator with R58 cartridge. Approval number TC-23C-106. Safety Products Division, American Optical Corp.

-- Pulmosan number C-241 respirator with TC-23C-81 organic vapor cartridge and C-241-7 filter. Approval number TC-23C-110. Pulmosan Safety Equipment Corp.

Powered Air Purifying Respirators

-- 3MW262 and W263 powered air purifying respirators with W2114 cartridge and W2031 filter. Approval number TC-23C-78. 3M Co.

Gas Masks

-- MSA Clearview or Ultraview Chin Style Gas Mask Systems with Pesticide Approved Canister (Numbers 448983, 448984, 448985, and 448986). Canister alone is 448972. Approval number TC-14G-86. Mine Safety Appliances Co.

Reentry Into Treated Fields - (Don't confuse with number of days from last spray to harvest).

These standards were established in 1974, apply particularly to agricultural uses and were established to protect workers. Although you as the commercial applicator may feel that you are not directly involved, there are some rules you must follow. These are:

1. No unprotected person may be in the field you are treating with any pesticide!
2. No pesticide application is to be permitted that will expose any person to pesticides, either directly, or through drift, excepting those involved in the application, who should be wearing protective clothing as required.
3. The label restrictions and directions must be followed.

Those pesticides presently (October 1975) restricted and requiring workers to wear protective clothing within the 24- or 48-hour reentry period after treatment are:

24 hours	48 hours	
Guthion	ethyl parathion	carbophenothion
phosalone	methyl parathion	Meta-Systox-R
EPN	demeton	Bidrin
ethion	Azodrin	endrin

It is your responsibility to keep abreast of changes in these pesticide restrictions.

Although not absolutely necessary any time that you apply one of the above materials, it is recommended that you notify your client to avoid misunderstanding, poor public relations and possible litigation. Tell him the name of the material, time of application and the required reentry period during which protective clothing must be worn so that he may inform his employees accordingly. If workers must enter fields prior to expiration of the required interval, growers are obligated to notify workers of the date of treatment and furnish them with protective clothing.

Fields treated with pesticides other than those listed above may be re-entered without protective clothing after the spray has dried or the dust has settled. New labels will indicate the necessary reentry information, old labels will not (refer to list above).

State regulatory agencies may impose and enforce standards for workers that are more restrictive than those specified. Check your state regulations.

Days to Harvest Interval

Don't confuse days-to-harvest intervals with reentry intervals. Days-to-harvest is the time that must pass between pesticide application and crop harvest to protect the consumer by allowing the pesticide residue to fall to or below a specific tolerance level. The same pesticide will have different intervals for different crops, based on dosages necessary to control pests, different surfaces treated, whether edible parts are treated, stripping or washing outer leaves, etc. Check the harvest interval before an application is made.

Hazards to the Crop

Probably the greatest hazard to the crop is an adverse reaction to the chemical applied. "Phytotoxicity" or chemical injury results in stunting, burning, deforming, or death of the crop.

Phytotoxicity or Chemical Injury

Pesticide injury to plants may be the result of direct application to the plant; spray, dust, or vapor drift onto the plant; runoff from a treated field or persistent soil residues which can damage a sensitive crop planted in an area previously treated. Injury to the plant may appear as dead, burned, or scorched spots on or at the tips of leaves; russeting of fruit; misshapen fruit, leaves, or plants; off-color; stunting; delayed development; poor germination; or complete death of the plant. Unfortunately, these signs of chemical spray injury often do not appear until several days after application. When they do appear, they are not always clearly understood and they are often confused with other problems such as: signs or symptoms of a disease; insect injury; uneven application of fertilizer; nutrient deficiency or excess; poor

drainage or poor soil; frost injury; hail, drying winds; hot weather; shading; poor lighting; or air pollution. Generally, however, there are clues which help you solve the problem. Some are: location of injured plants; location of injured areas on the plant or fruit; nature of the injury itself; lack of signs of other causes of the injury such as ooze or fungus growing from the injured spot; weather records; cropping history; location in relation to highways, industrial plants, cities; etc. Sometimes it may be necessary to call upon experienced people to help determine the correct answer. Generally, the injured areas are sharply defined between injured and healthy tissue. Color of the injured area is usually uniform. Spots may be evenly distributed or confined to a spot where a drop of spray accumulated on the low area of the leaf or fruit.

The likelihood of plant injury resulting from the use of a pesticide varies with the chemical, the formulation used, the concentration, the method of application, the growing conditions and the stage or condition of the plant. Desiccants, defoliants and herbicides are effective because of their ability to kill foliage and destroy plants. They are, therefore, particularly hazardous through drift to sensitive plants. Organophosphates, carbamates, and oils are more likely to cause injury when drying conditions are poor. Chlorinated hydrocarbons, on the other hand, are more apt to be injurious in hot, dry weather. Emulsifiable concentrates, because of the solvents in them, are more likely to cause injury than wettable powders since they allow the chemical to come into direct contact with the plant tissue by dissolving the waxy protective layer on the leaves. Mixtures of pesticides, especially soluble or emulsifiable formulations, are more likely to cause injury in sensitive situations than materials applied individually. Similarly, applications with high pressures may cause injury when lower pressures would not. Injury may appear at the end of rows or near the edges of treated fields because of slower travel rates, turning and stops. Phytotoxicity may result under some of these conditions even when recommendations are followed. Severe injury, however, is unlikely and is a sign of other problems.

Growing conditions can also influence plant sensitivity to chemical injury. Weak plants such as those in shallow soils, wet spots, etc., are more susceptible to injury than are healthy plants. Young, tender, fast growing

plants with large areas of new growth tend also to be more susceptible to injury. Differences in the sensitivity of varieties is not uncommon.

Hazards to Non-target Areas or Organisms

These hazards are the result of a pesticide hitting the wrong target within the crop, drifting away from the crop, or being mishandled.

Hazard to Bees (See inside of back cover)

Honey bees and wild bees are necessary for pollination of many crops. Many pesticides are highly toxic to honey bees, wild bees and other beneficial insects. You can reduce bee poisoning if you follow these suggestions:

-- Do not apply pesticides that are toxic to bees to crops that are in bloom, including cover and adjoining crops.
-- Select pesticides that will be least harmful to bees.
-- Try to choose the least harmful formulations. Dusts are more hazardous than sprays. Emulsifiable concentrates seem to have less residual toxicity than wettable powders. Granular formulations have the lowest hazard to bees.
-- Try to time pesticide applications so that the hazard to bees will be as low as possible. Evening applications are generally less hazardous than early morning. Both are safer than mid-day applications. For example, short residual pesticides might be applied at night between sunset and sunrise to minimize injury to foraging bees in the field needing treatment. Because corn and milo stop shedding pollen about noon, and bees collect the pollen, short residual pesticides should be applied in mid-afternoon or evening to protect the bees.
-- Do not treat near hives and try to avoid pesticide drift over or onto hives. Coarse sprays will help reduce drift. If a hazardous pesticide must be applied near hives, contact the beekeeper ahead of time and ask him to remove his bees.
-- When a cover crop is in bloom, as in an adjoining field, the grower may be able to greatly reduce the hazard by mowing it before treating.

Drift

Pesticides are not pollutants as long as they stay on target. Drift of pesticides away from the target is probably the most important and costly

problem facing most commercial applicators. Drift is important because of possible injury to non-target plants and animals, and illegal residues that may make neighboring food crops unsalable. Poor public relations with those living around the target area may cause the loss of use of effective pesticides because of their side effects, and may result in loss of certification because of misuse.

Drift is costly because of: possible lawsuits resulting from off-target injury or unsalable crops; local public reactions that may prevent a potential program from being developed and carried out, and most important to commercial applicators, the loss of working time because of conditions that will cause harmful drift. The control of drift is <u>your responsibility</u>!

You, as a commercial applicator, have legal liabilities. You can be fined up to $25,000 and sentenced to one year in prison for gross misuse. You may also face loss or suspension of certification. Additionally, smaller misuses and penalties can seriously hurt your reputation.

Almost any pesticide application will result in some drift, which can be serious or relatively harmless. Ideally you should work when there is no wind. Practically speaking this is not often possible. But, if there are sensitive areas downwind, i.e., homes, pastures, water, sensitive crops, etc., you can often arrange your schedule to treat the sensitive areas when there is little or no wind, usually in early morning or evening. Less sensitive areas can be treated when the weather conditions are not as good. The risk is less if the crop downwind calls for the same pesticide as the target, or if the area to be treated is located away from houses, streams, or other such areas. You can sometimes influence your clients to plant high risk crops in low risk areas. You simply must have the good judgement to stop treatments when conditions are too poor. Such action may save you money and your reputation.

The machinery you use will influence your drift problems. If you use granular applicators, generally you will not have a great drift problem (although broadcast application in high wind will result in a poor application pattern). Sprayers cause more drift than granular equipment and the amount of drift varies widely according to the type of sprayer. Power dusters are no longer widely used, one reason being the excessive drift that results from their use. You can reduce drift by setting your equipment correctly for a particular job. Remember:

-- There is more chance for drift with airblast sprayers than with boom sprayers.
-- There is more chance for drift with high pressure sprayers than with low pressure sprayers.
-- Low volume concentrates are more apt to cause drift damage than high volume dilute mixtures.
-- ULV sprayers present the greatest hazard for drift because the droplets are necessarily fine in order to get coverage.
-- Smaller droplets drift further than larger droplets.
-- The higher the boom or nozzle from the crop, the more chance for wind effect and drift.

If you keep these principles in mind you can operate your equipment to minimize drift.

When using airblast equipment, follow these practices to reduce drift:

-- Direct nozzles with the airblast to give coarsest droplets that will be effective.
-- Use lower pump pressures to give larger droplets.
-- Determine the effective swath width and calibrate. Plan the spraying pattern of the field accordingly.
-- Operate in little or no wind. Not only will wind cause drift, but it will distort the swath pattern.
-- Choose a time to operate when drift is away from sensitive areas.
-- When spraying near sensitive areas be sure the airblast is directed away from them.

When using boom equipment, follow these practices to reduce drift:

-- Use lower pressures and spray discs with larger openings to increase droplet size. Using higher total volume per acre will allow larger droplets without reducing coverage.
-- Choose the best type of nozzle. Hollow cone nozzles produce more "fine" droplets than flat fan nozzles. Newly developed nozzles are available that collect these "fines" together into larger droplets while they are still within the nozzle, thus reducing drift (fines can drift long distances).

-- Keep booms mounted as low as possible to reduce wind effects. Use closer nozzle spacing and wider fan angles.
-- Position boom to give larger droplets if ground speed is high (10 - 15 mph). Tilting the boom forward results in finer droplets; tilting backward gives larger droplets.
-- Be sure sprayer is properly calibrated -- don't overdose.

Your choice of chemical and formulation has a significant effect on drift. Granules do not ordinarily drift very much because they are relatively large and uniform in size, although toxic dust can escape from some formulations. Dusts can drift badly because the particles vary widely in size and include a high percentage of small lightweight particles.

Many sprayers produce vast numbers of "fines". You can reduce fines by physical means - lowering pressure, using larger nozzles, etc. Materials called adjuvants that act as thickeners or foaming agents can be added to the spray tank. These materials increase the number of larger droplets and decrease the number of fine droplets. Some are simply added to the tank and others are pumped through special mixing pumps and/or nozzles. Sometimes the spray is thickened and other times it is made into a foam. All such adjuvants reduce drift by reducing the number of fine droplets, but no method makes a spray drift-proof.

In addition to actual particle or physical drift, certain materials vaporize, thus producing fumes which may cause damage for long distances downwind. These materials are "volatile" and include esters of 2,4-D, 2,4,5-T and other phenoxy compounds, dinitros, and some carbamate herbicides. Volatile forms can vaporize rapidly at 65 degrees F and high temperatures of 80 to 90 degrees accelerate vaporization of the volatile formulations and even low volatile esters of 2,4-D type herbicides. Amire formulations are usually considered non-volatile although extremely sensitive plants can sometimes be damaged. Obviously, you would choose an amine formulation rather than a high volatile ester in a sensitive situation. Spray on the coolest part of the day. Avoid high temperatures and low humidity.

Contamination

Pesticides need careful attention even when they are intentionally placed on a target, placed in storage, located in a sprayer or on a truck. They often appear where they were not placed or wanted and thus cause problems.

Such places include our general surroundings (air, soil and water) and also our more intimate surroundings (equipment, storage, clothing, shoes) and even within our bodies. Some pesticide residue is purposeful, as when spraying a crop or applying a preemergence herbicide. Some is expected, like the residue in a sprayer; but some is unwanted and may be an inconvenience, contaminant, or hazard. Since your contact with pesticides is greater than that of the average person, you must be particularly careful not to over-expose yourself.

Every pesticide application that is made in the field will result in some air and soil contamination, which may be followed by contamination of water. The extent of this contamination will depend on several choices that you make. Your first goal is to keep the pesticide within the target area. (During some spraying operations more than 50% of the pesticide fails to reach the target and cannot be accounted for, except that it escapes into the environment). Secondly, you must consider drift, runoff, soil erosion by wind and water, volatility of the pesticide, persistence of the pesticide, plant absorption, use of minimum dosages, etc. All of these factors will be influenced by your choices of pesticide and formulation, application equipment, weather condition, filling practices, calibration and clean-up techniques.

You must choose the best pesticide: one that will give effective control, be persistent enough to do the job, yet break down when it is no longer needed. Pesticides usually persist longer in soils of high organic content than in light mineral soils. If you are working near water you can choose the pesticide least harmful to aquatic life that is registered for the use intended. Certain herbicides depend on persistence for effectiveness and can cause problems if susceptible crops are planted too soon in the treated area. Many of the chlorinated hydrocarbons -- DDT, dieldrin, aldrin, etc., were highly effective, but so persistent and accumulative that their use has been drastically cut back or prohibited. The choice of pesticide also includes choice of the best formulation. The applicator wants the pesticide to stay within the area treated. Therefore, he will use the formulations that will be less likely to cause drift and may use anti-drift adjuvants.

Even though the pesticide remains in the treated area, it would be wise to check the fences and notify the owners if livestock graze nearby. You should also warn your client about any restrictions on grazing or feeding of

the treated crop, so that no poisoning of livestock or contamination of meat or milk results. You may wish to use a less toxic or less limited pesticide if working near livestock.

Here are some tips that you may follow to improve your operation and cut down on local contamination. 1) How do you carry your pesticides and other supplies in your truck or trucks that service your sprayers? Rather than riding loose in the back of the truck they should be enclosed. Built-in lockers are convenient if you can get them, but a locked storage chest will be adequate. 2) You also need a place to hold the empty containers that you don't burn in the field. 3) A first aid kit in the cab of the truck can literally be a life saver. Plastic eyewash bottles that have a flushing action can also be carried in the cab. 4) A container of clean water fastened somewhere on the outside of the truck with detergent and hand cleaner nearby is also worthwhile for washing off spills, splashes or other skin contamination. A faucet or valve on the container will make it easy to control water flow.

5) If you transport pesticides over the highway to sprayers in different locations you may accidently spill concentrates on the highway. Keep a shovel, stiff broom, and neutralizers (Clorox, lime) on your truck. Don't forget to call local police and health officials if the spill is too large for you to handle safely yourself. 6) You should have boots, gloves and a respirator handy if the pesticide you are carrying and applying is toxic enough to require them. This same equipment can also be used for spills of concentrated pesticides in the field.

7) Are you filling from a well? Who else is using it and for what purpose? Use a separate pump with check valves to prevent back siphonage and be sure the filler hose does not dip into the sprayer tank. If you mount the right size hook to hold the filler hose, you won't have to hold it and there will be no chance of its dipping into the tank. Be sure your sprayer doesn't overflow and drain pesticide contaminated water back into the well. If the well you are using is the source of domestic water or for watering cattle, you may want to fill elsewhere. Even if you fill elsewhere, you should take the same precautions (cattle drink from ponds and fish live in streams).

Suppose you do contaminate the well. What then? First, contact your county or state health official. Usually your actions will depend somewhat on the toxicity of the pesticide involved and how tightly it fastens to particles in the water and on the walls of the well. With materials of low or moderate toxicity, the well should be pumped dry, allowed to recover and pumped again. Addition of a charcoal slurry will help absorb the pesticide. Clorox or another chlorine compound may help break down the pesticide. The well should be pumped dry after the addition of any of these absorbents or neutralizers. Domestic and barn plumbing should be thoroughly flushed after the well is decontaminated and before any water is used. If the contamination was of highly toxic materials, a chemical test should be made before the water is used. If the well cannot be purified you may be liable for a new water supply. Prevention of contamination may be vital to your business.

8) Your sprayer filling station can be designed to minimize problems. Frequently filling stations are on pond or stream banks and the natural flow is back into the water. Grading the area to slope away from the water will prevent this problem and allow you to neutralize an unplanned spill so that it does no damage. 9) Another common problem with these areas is disposal of "empty" pesticide containers. Much too often they end up in the water. A trailer, old truck van, or some other storage place, in which used containers can be held safely for disposal, will prevent this contamination.

10) There are two main possibilities for contamination at your storage and clean-up area: chemically contaminated runoff from wash water or fire fighting water, and exposure to yourself or other people. Your core manual tells you how to avoid runoff problems. 11) The right precautions will help you avoid exposing yourself during clean-up or repairs. Dress properly for clean-up as well as for mixing or application. The residue that you scrub off the outside of your equipment may be more concentrated and toxic than the spray itself. Don't scrub the surface with your bare hands or a rag which will soon be loaded with the chemical. Instead use a scrubbing brush with a handle and, if necessary, rubber gloves. Check the label if you are in doubt.

12) Often you need to clean and check your sprayer booms, hoses and nozzles when there is spray material in the tank. Rather than use contaminated

water from your tank you can hook a hose to the discharge side of your spray pump and do your cleaning with uncontaminated water from your domestic water supply. This is particularly convenient if your spray tank has spray mix in it. Remember, however, that the first discharge from the nozzles will be spray mix. Remember also that back siphoning can occur even in pressure water systems if there is a sudden heavy drain on the system.

13) Normally, you will not get inside your spray tank. However, you may have to make repairs that require you to do so. If so, remember that it is probably a highly toxic area. Avoid working alone. Wear full protective gear to prevent both dermal and inhalation toxicity. Even outside the tank welding may generate highly toxic fumes. Use a respirator.

14) Personal contamination or poisoning can also be caused by lying on contaminated ground while making repairs to machinery. Move the equipment to an uncontaminated area, or use a creeper, piece of linoleum or something similar to protect yourself.

As in other areas of pesticide handling, the best preventative for contamination is your own awareness and good judgement.

Specific Use Problems

Some categories of pesticides have special problems that require your attention over and above the usual awareness.

Herbicides and their use are growing rapidly and now represent the largest single group of pesticides used in agriculture. Although, as a group, they are relatively low in their hazards to humans and to wildlife, they are not without hazard, and some are highly toxic. However, it must be remembered that the greatest hazard associated with herbicides is their phytotoxic effect on non-target plants caused by incorrect or inaccurate application. Misapplication of herbicides may occur as a spray drift of droplets, particles, or vapor, as soil contamination resulting in absorption by roots of non-target plants, as excessive soil persistence causing injury to later crops, and as sprayer contamination. All must be avoided!! All produce obvious damage but by the time they are visible it is too late to remedy the cause.

Plant growth-regulating or hormone-like herbicides produce the greatest hazard to non-target plants. Although these chemicals are primarily used to check growth of broadleaf plants, crops such as wheat, oats, barley, milo, corn and turf grasses can be seriously affected as well.

Spray drift of soil-applied non-crop herbicides such as fenac or 2,3,6-TBA can injure sensitive crops such as beans, even when the drift has occurred before planting. All herbicides are subject to drift for considerable distances. Some, however, such as those listed below present a particular hazard to non-target plants from drift. All of them except dinoseb, propanil, and paraquat are of the plant growth regulator type and can cause abnormal plant growth even in trace amounts.

EXAMPLES OF HERBICIDES THAT PRESENT A PARTICULAR HAZARD TO NON-TARGET PLANTS FROM DRIFT

2,4-D	mecoprop (Mecopar)
2,4-DB	paraquat
dicamba (Banvel)	picloram (Tordon)
dichlorprop (2,4-DP)	propanil (Stam F-34, Rogue)
dinoseb	silvex
fenac	2,4,5-T
MCPA	2,3,6-TBA (Benzac, Trysben)
MCPB	

Sprayer contamination is also most likely to result from the materials listed above. If the sprayer is used for other purposes, decontamination is a problem. Repeated flushing with water is not a dependable method to remove herbicide residues from any spray tank, pump, hose, boom and by-pass system. Emulsifiable formulations such as esters and oil soluble amines are more difficult to remove than water soluble metallic and amine salts. Wooden tanks are almost impossible to decontaminate. If you must decontaminate, circulate a solution of household ammonia or detergent (1 quart to 25 gallons of water preferably warm) through the sprayer at operating pressure, including hoses, booms, and nozzles. Let stand for several hours, drain, flush, add more water. Test by spraying sensitive plants such as bean or tomato seedlings. Injury will usually appear in 2 to 7 days if the sprayer is still contaminated

Soil persistence of herbicides is important in selecting an herbicide. You must consider the crops that will follow if problems are to be avoided.

Soil persistence is dependent on many factors including rate, formulation, and method of application of the herbicide, as well as soil type, microbial populations, soil temperature, moisture, and tillage. In general, herbicide breakdown is most rapid in warm, moist soils with good microbial growth; it is more prolonged by cold, dry, sterile soils. Alachlor, butylate, endothall, TOK, paraquat, and silvex are a few examples of some herbicides with relatively short soil persistence (1 to 2 months) based on weed control. Materials like atrazine, benefin, bromacil, dicamba, diuron, picloram, terbacil and trifluralin are examples of herbicides persisting for six months or more.

Special Use Pesticides

Growth regulators, desiccants, and defoliants are chemicals that can be used to improve crop performance, production, storage or handling procedures, rather than to control a particular pest. Slight variations in the methods of use of these chemicals can have significant effects on their performance: the same chemical may produce different or even opposite effects on the same crop, depending on the rate of application and weather conditions, as well as differences in age, stage of development, rate of growth, and vigor of the plants.

Growth Regulators

Growth regulators may be used in very small amounts either to stimulate or to reduce growth, flowering, or fruiting. They are used in the production of fruits and nuts, vine and small fruits, vegetables and field crops. Materials such as napthalene acetic acid (NAA), napthaleneacetamide (Amide), naphthylpthalamic acid (NPA), and carbaryl, when applied after bloom for blossom thinning, upset the physiology of the flower or fruit causing the seed to die and the fruits to drop from the tree. Other materials such as dinitros, used in bloom, are caustic and burn some of the flowers off. Some growth substances may be used to improve fruit set, prevent excessive fruit drop, or to control the time of fruit maturity. Other materials have been used to increase bloom the following year. Because of the sensitivity of plants to these chemicals and the small quantities used, extra precautions must be carefully observed to use precisely the right amount of chemical at the right time on the specific varieties intended for treatment. In these applications equipment calibration is vital. Application is usually made as a foliar spray, a

soil drench or by bark injection. Particular care must be taken to avoid drift with foliar sprays and timing is usually critical.

Sprout inhibition is another form of growth regulation, in which chemicals are applied to crops such as potatoes and onions to prevent sprouting in storage. Inhibitors should not be applied to potatoes or onions intended for use as seed. Treatments may be made in the field prior to harvest (i.e., maleic hydrazide to potatoes or onions) or in storage after harvest (Chloro IPC as a dip or spray during grading or as a vapor or aerosol applied in the ventilation system of the storage).

Growth regulators also include chemicals which break dormancy in plants or plant parts, and speed up root formation and elongation. This category does not include fertilizers and plant nutrients although they are sometimes sprayed on crops -- particularly fruit trees. Do not combine fertilizers or plant nutrients with pesticides.

Desiccants and Defoliants

Some chemicals are used to cause the leaves to drop from crops such as cotton, soybeans, or tomatoes to make harvest easier without killing the plants. Such chemicals are called defoliants. Other chemicals, desiccants, are intended for speeding up the drying of plant parts to aid in the harvesting of some seed crops (alfalfa, clover, sorghum), potatoes, dry beans and nursery stock. Frequently the terms are used interchangeably and depending on the amount applied some defoliants also act as desiccants. Sometimes mixtures are used (i.e., cotton) and these combination materials are called "harvest-aids".

Some of the advantages of using defoliants or desiccants are: 1) reduction of disease or insect populations, 2) killing of weeds which interfere with harvest, 3) aid to and simplification of mechanical harvesting, 4) quality improvement, 5) reduction of storage crop disease, 6) reduction of the moisture content of seed, and 7) yield increases. Disadvantages may be: 1) a reduction in yield and quality, and 2) toxic residues.

Complications can result from the use of these materials, so you must take great care in their selection and use. For example, the use of some materials on potatoes causes discoloration at the stem end of the tubers.

Other materials cannot be used on potatoes that are to be stored without increasing the risk of storage rot. Slower kill of the vines may be preferable to a faster kill. Other factors such as soil moisture, cultural or climatic conditions, stage of growth (flowering plants are not easily desiccated), and stage of maturity are important considerations. Be sure you have all the information needed before using any of these materials. Injury is readily visible, even if minimal. If additives are specified on the label, use only those recommended. Crops treated with a desiccant generally cannot be used for grazing, and many do not permit use of the seed for food, feed, or oil purposes. Before using a defoliant or desiccant on a crop, be sure that the remaining part of the crop is not going to be used as food or feed.

Soil Pesticides

The soil is the most complex medium you will treat for the control of pests. Soil treatments include the use of variously formulated insecticides, fungicides, nematicides, and herbicides. Success in soil pest control requires: 1) knowledge of the pesticide: volatility, water solubility, absorption rate and rate of breakdown; 2) knowledge of the characteristics of the soil being treated: sand, silt, organic matter content, texture and structure, temperature, moisture content, and air movement; 3) requires knowledge of the pest: its stage of development and its susceptibility to pesticides. An understanding of these factors and how they relate to each other is essential.

Soil pesticides can be grouped in two categories -- volatile and non-volatile.

Volatile - Fumigants

Those that are volatile are called fumigants. They vary from broad-spectrum materials to those that are very specific; from those having very short residual effectiveness to those with longer residual effectiveness; and those which are highly volatile to those having low volatility. Some are available under pressure as liquids but are released as gasses under covers (tarpaulins). Others are liquids but vaporize after being placed in the soil.

The dose of a soil fumigant necessary to kill pests depends on the concentration of the chemical in the soil and the amount of time the organism is

exposed. This is influenced by soil conditions -- soil type, moisture level, etc. Recommended rates are selected to perform satisfactorily over a wide range of soil conditions.

The effectiveness of chemical treatment also depends upon the temperature and moisture of the soil and the depth to which it is treated. If the soil is too warm or too dry and the fumigant injected too shallow, six inches or less, the gas may escape too fast for good control; and if too cool, diffusion may be too restricted to obtain good control. [If too wet, the water occupies most of the air space, more fumigant dissolves in the water, the fumigant that is left as a gas moves very slowly, distribution is poor, and control is poor. Soil fumigants perform best when soil is only moderately moist, somewhat drier than seedbed condition, and the soil temperature is between 50° and 80°F. Frequently a fall treatment provides better results than a spring treatment because of more favorable temperature/moisture relationships in the fall. The fumigants should be injected deeper than six inches. The soil surface should be sealed by some effective method of soil compaction.]

Soil structure and condition also influence the effectiveness of fumigants. Generally fumigants move faster in loose and sandy soils than in clay or compacted soils. Control will be better in well-tilled soil with high content of organic matter than in poorly-prepared cloddy soil. Highly organic soils may absorb or "tie up" the fumigant, and soils with plant residues (stalks, vines, etc.) may protect nematodes and other pests from the fumigant, as well as reducing effective injection and seeding.

Aeration time (the time needed to allow the fumigant to leave the soil) is important to avoid injury to the crop. It varies with the chemical, soil temperature, moisture, texture, and the crop to be planted. Fumigants such as ethylene dibromide, methyl bromide, and dibromochloropropane (DBCP), leave appreciable residues of bromine in the soil. These residues are toxic to some plants (onions are very sensitive) and are taken up by others (many forage and feed crops). DBCP causes severe damage to tobacco, potatoes, sweet potatoes, garlic and some types of pepper.

Some fumigants applied under tarpaulins may reduce the nitrifying bacteria populations of the soil and therefore, nitrate fertilization is required following treatment to correct this condition.

Non-Volatile - Non-fumigants

The non-fumigant soil pesticides are non-volatile and vary in their characteristics: from high to low water solubility; from non-systemic to systemic in their activity; and from little (short residual) effecti eness to long (residual) effectiveness.

Non-systemic pesticides must be directly placed on the site of action (carried by water for instance) or must depend on the plant to grow to the material. Pesticides having systemic action may be translocated upwards or downwards through the plant, or in both directions; therefore, it is not necessary to apply the pesticide directly to the part of the plant to be treated.

Non-fumigant soil pesticides are usually dependent upon the presence of soil moisture. Moisture is often needed to activate or release the pesticide, to move or distribute it into or through the soil, and to allow absorption into the plants. Materials that are highly water soluble need less water than products of low solubility in water. Those materials having low water solubility, high evaporation rates, sensitivity to breakdown by sunlight, or high absorption rates on soil particles, usually require mechanical incorporation (physical mixing) into the soil, regardless of rainfall or irrigation.

As with fumigants, non-fumigant soil pesticides are less effective or require higher rates of application in soils high in organic matter, in fine clay or silt soils, and at temperatures less than optimum. Best results can be obtained if you know the soil type and organic matter level of the fields you treat. For future jobs, keep records of materials and the results obtained.

Safety

Pesticides vary in potential toxicity to the applicator and the environment. The fumigants are generally classified as moderately toxic, whereas the non-volatile pesticides range from extremely toxic to relatively non-hazardous. It is important that the toxicity of each pesticide be known before use. The label will tell you, but in the absence of such information, any pesticide should be considered extremely toxic. Proper safety equipment and clothing should be worn when highly toxic pesticides or pesticides of unknown toxicity are being used. Likewise, potential environmental pollution should be recognized, and proper precautions taken. Again, the label will warn of hazards, and list the precautions that should be taken.

Combinations or Mixtures of Pesticides, Mixing and Compatibility

Mixing pesticides in the spray tank is an old and widely used practice. A mixture of an insecticide and fungicide or an insecticide and an acaracide is often used on fruit and vegetables to save an additional application. Different herbicides are sometimes mixed to broaden the spectrum of activity. A grass killer may be combined with a broadleaf killer, or a product particularly effective against one particular species may be added to another of more general activity to broaden the spectrum of effectiveness. This is practiced with insecticides as well as with herbicides. Sometimes a mixture of products is used to increase effectiveness against a single pest species. Many of the newer pesticide labels specifically list the mixtures that can be made with that pesticide.

Under present federal regulations, uses of pesticides inconsistent with (or not mentioned on) the labeling are a misuse and unlawful. The legislative history shows, however, that it was the intent of Congress that EPA be reasonable in interpreting and enforcing misuse provisions. Accordingly, EPA has interpreted the legality of tank mixing of pesticides and set a policy that will be in effect until modified by further statements or regulations.

Tank mixes may fall into one of three acceptable categories:

Category 1 - Instructions provided on label

instructions for tank mixing are provided on one or more labels of EPA registered products. Such uses are fully consistent with the label and no further clarification is needed.

Category 2 - Registered intrastate

tank mixes are covered by state registrations. Such registrations are valid until replaced by EPA registrations scheduled to be completed by October 1976. If a product use is cancelled or suspended from interstate commerce at the federal level before such time, the state registration is also cancelled. To date the only products involved are DDT, aldrin and dieldrin. Otherwise state use registrations are valid.

Category 3 - Recommended by state agencies or with a history of use

tank mixes have been tested and recommended by cooperative extension, state agricultural experiment stations, state departments of agriculture, or are recognized as common agricultural practice. These are acceptable provided the dosage rate of any pesticide in the mix does not exceed the label instructions for the same product used singly, and provided that the label does not specifically instruct against such a mixture.

EPA has not reviewed those uses in Categories 2 and 3. While such uses are legally acceptable as to consistency with label instructions, this does not mean that EPA has approved them in regard to either efficacy or human and environmental safety data. Therefore the user applies them at his own risk.

If adverse effects are observed from any particular tank mix EPA may consider these uses on a case-by-case basis and rule them inconsistent with the label.

In summary, tank mixes and serial applications are ruled consistent with the label and recommendable if:

a) the label specifies such uses,

b) there is a state registration for such uses, or

c) such uses are recommended by state agencies or are common agricultural practice.

Even when pesticides are approved for use in a mixture, problems may still result. Formulations of a particular pesticide vary from one product to another, and incompatibility may result from the different wetting agents, solvents, and other additives in them. Liquid formulations are particularly susceptible to incompatibility problems due to the many additives they usually contain. Incompatibilities are expressed in different ways, but a crystalline precipitate or a gelatinous mass is common, which would require time to clean out plugged nozzles, screens, and regulators. Another common result is a break in the emulsion in which the different ingredients separate out as would oil and water. This is the result of the emulsifier being destroyed, and spray injury is likely to result. Sometimes the addition of soluble salts to the spray tank will cause an emulsion to break. Separation can also take the form of clumping of particles together. This is called agglomeration.

Incompatibility can also result in lessened activity of the combination although no visible problems can be seen. The combined materials inactivate one another, and the resulting mix will be less effective.

Hardness of the water may also affect a pesticide or mixture of pesticides. Phosphate and carbamate materials are more susceptible to high alkalinity than other pesticides. The addition of lime, lime sulfur, Bordeaux mixture or other highly alkaline materials may cause decomposition, loss of toxicity, or phytotoxicity.

Combinations of oil or petroleum solvents with organic chemicals frequently are very injurious to plants. Many emulsifiable concentrates are formulated with petroleum solvents and fall into this category. When two emulsifiable concentrates are combined, the pesticides may be compatible but the solvents or emulsifying agents may not be and injury may result.

Many cases of incompatibility are reported for combinations of emulsifiable concentrates and wettable powders. Sometimes one or both pesticides precipitate or fall out of the mixture and spray injury to the crop is the frequent result. In other cases, mixing may cause excessive residues although no precipitation is noticeable in the tank.

Most agricultural emulsifiable sprays are oil-in-water emulsions producing small particle sizes. Invert emulsions, water-in-oil, are usually less desirable for insect and disease control but, because of the larger droplets, may be more desirable for herbicides. When difficulties in emulsifying an oil- or pesticide-in-water spray are encountered, they can usually be corrected by starting with just enough water to cover the agitator, then starting the engine and running the agitator and the pump at full pressure to force the liquid through the by-pass return to the tank. If an additional or separate emulsifier is to be used, it should be added to the tank before adding the pesticide or oil. Allow the pump to run for two or three minutes. Once this emulsion is formed, add the rest of the water to fill the tank while the pump and agitator are running. Invert emulsions usually require special equipment in which a special mixing chamber is used between the pump and the nozzle.

Although incompatibility may still be a problem, it can frequently be reduced to the minimum by:

1) Using formulations produced by the same manufacturer.

2) Keeping the equipment clean and well drained.

3) Never putting pesticides in an empty tank. The tank should always be partially filled before adding the pesticide.

4) Never combining concentrates, but diluting them first.

5) Mixing wettable powders with water to form a slurry before they are added to the tank (unless you have an inductor system).

6) Adding wettable powders to the tank before the emulsifiable concentrates.

Mixtures of Pesticides and Fertilizers

Many of the principles for using tank mixtures of pesticides also apply to fertilizer-pesticide mixtures. The most important point to remember is that such mixtures, either wet or dry, should be handled as pesticides, not fertilizers. In some states there are specific regulations governing use of fertilizer-pesticide combinations. Check your local state situation, or if you cross state lines -- make sure you are operating within regulations.

Pesticides are precision tools. The total quantity of a pesticide in the tank may be less than the accepted variation in fertilizer application which may vary from a plus or minus of 10 to 15 pounds per acre. Timing, placement, and distribution are frequently different for pesticides and fertilizers. Compromising one requirement may limit the usefulness and safety of the mixture.

Where tank mixtures are to be used, make sure that agitation is adequate to maintain the suspension. Suspensions also require about one to two gallons of spray carrier for each pound of product to be suspended. Some products are specifically formulated for use in fertilizer mixtures. Others specify the need to check emulsion stability and add a compatibility agent if needed.

Serial Applications of Pesticides

Serial applications of pesticides are applications in which the pesticides are applied individually but following one after another. Although the time is generally limited to a few days, it can be longer. Regulations governing serial applications are the same as for tank-mixtures of pesticides. Problems arising from incompatible serial applications may be plant injury, loss of

effectiveness of one or both pesticides, excessive residues, etc. This is particularly true if oil is applied before or after a pesticide or nutrient spray.

Adjuvants or Spray Additives

Pesticides, whether emulsifiable concentrates or wettable powders, are formulated for general performance purposes under average conditions. For many jobs they perform satisfactorily, but there are also many situations where they fall short of the desired effect. For example, in very hard or soft waters, a formulation may have too little or too much emulsifier, with the consequent problems of difficulty in mixing or of excessive foaming. A formulation may evenly distribute a pesticide on the leaves of crops such as beans and potatoes satisfactorily, but on the waxy leaves of cabbage, cauliflower, or onions, the spray, instead of spreading as an even film over the leaf surface, may form small, round droplets. It then runs off of the plant and onto the ground, leaving no deposit to protect the plant. The addition of a surfactant to the spray tank will solve this problem. Recently it has been common to add to herbicides materials which improve their effectiveness by increasing their ability to wet and penetrate treated surfaces. A substance added to the spray mixture to aid or improve the performance of the main ingredient is an adjuvant.

Adjuvants may be added to the spray mixture to:

1) Improve the wetting of the foliage or the pest.
2) Change the evaporation rate of the spray.
3) Improve the ability of the spray deposit to resist weathering.
4) Improve the penetration, absorption and translocation of the pesticide.
5) Adjust or buffer the pH of the spray solution increasing the effectiveness and longevity of alkaline sensitive pesticides.
6) Improve the uniformity and amount of the deposit.
7) Improve the ease of mixing or compatibility of the spray mixture.
8) Increase the safety from spray injury to the crop.
9) Reduce the drift hazard to neighboring crops.
10) Improve physical properties of the mixture -- i.e., anti-foaming agents.

Depending upon their intended use, adjuvants are called emulsifiers, wetters, stickers, extenders, spreaders, deposit builders, film formers, buffering agents, thickeners, penetrants, foaming agents, anti-foaming agents, etc.

Adjuvants are highly active materials. In most cases, a very small quantity will have great effect. You should be careful to use only the amount recommended. Too much adjuvant may be just as bad as too little -- it makes little difference whether the pesticide runs off the foliage because it balls up or because it forms too thin a film on the foliage. Also, too much adjuvant may cause herbicide spray to lose some of its selectivity and injure plants normally tolerant of it.

Regulations require spray adjuvants, for use with pesticides, to be registered and carry an EPA number and either to be exempt from the requirement of a tolerance or to have a tolerance established.

Proper selection of the adjuvant for your job is of the utmost importance.

II. PESTS

You can't solve a pest problem if you don't know the pest. Accurate diagnosis of the pest and its damage is essential in deciding what to do. If you are familiar with the pest you may decide to do nothing, because you know that most of the injury has already occurred, that the potential damage is less than the cost of chemical treatment, or that no effective chemical treatment is available. Additional damage caused by driving equipment through the crop may be greater than that caused by the pest. For further discussion on specific pests refer to the chapter in this manual that deals with your commercial category.

Identification and Diagnosis

Identification of the pest or pest damage is the most important step in controlling the problem. Thorough knowledge of the crop and its growth characteristics is essential. Otherwise, evidence for the presence of and damage by a pest may go undetected. To know and to recognize the causes of poor plant growth and the signs of pest injury require years of experience. This is one reason why people who diagnose pest problems prefer to work with a small number of commodities such as vegetables, forests, or turf. Even then, there is no substitute for experience; the accurate diagnosis of plant ailments is a skill requiring much time and effort to develop. Generalizations can be made, however, that will help identify the cause of some ills of plants.

Plants may be injured by animals such as insects and rabbits, by other plants (weeds), by fungi, bacteria, viruses and mycoplasmas, by environmental imbalances such as drought and nutritional deficiency, and by chemical injury such as air pollutants and sprays (see below).

Possible Causes of Injury to Plants

Animals	Other Plants	Microorganisms	Other
Birds	Dodder	Bacteria	Air pollutants
Dogs	Mistletoe	*Fungi	Drought or excessive moisture
Insects	Moss	Viruses	Lightning, wind & hail
Mites	Weeds	Mycoplasmas	Mechanical injury
Millipedes	Algae	Viroids	Mineral deficiencies
Nematodes			Spray injury
Rabbits, mice, moles, rats & others			Extreme temperature
Slugs and snails			Oxygen deficiency in soil

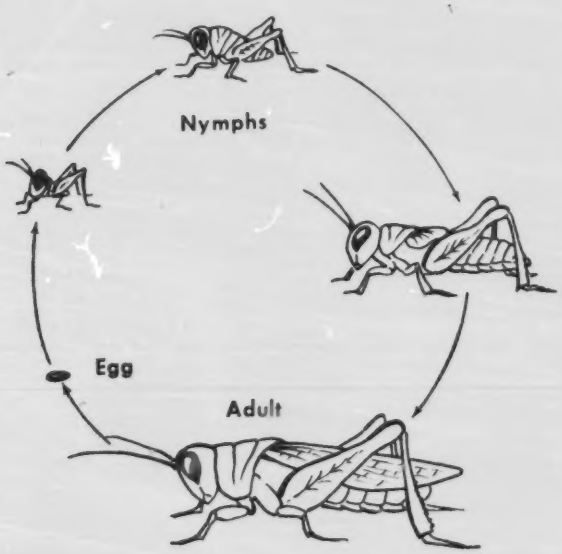
*Some fungi may be large in size.

The cause of damage is often revealed by careful observation. For example, a canker disease may have girdled a twig or limb causing the leaves to wilt or die. However, one must not only look at the leaf, but one must look carefully along the twig or limb to find the cause. Or, an insect may be eating the plant roots -- the symptoms first appear on the leaves, but until the roots are examined, the cause cannot be correctly identified. With careful observation, knowledge of the plant's history, and a general knowledge of possible causes within the geographical area, plant ills can frequently be diagnosed without the need of a specialist.

Possible and correct diagnosis of the problem is essential for effective control. Identification of pests is based on a thorough knowledge of the host and symptoms of damage, the part injured, time of year, etc. Identification of damage by location and host will be given in this manual following a brief treatment of some characteristics of the different pests.

1. Insects

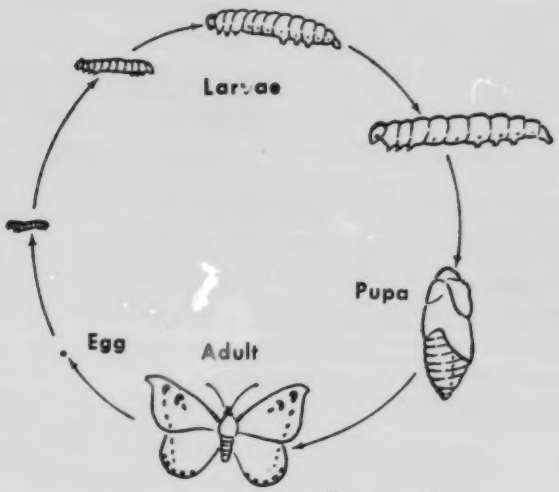
Most insects injurious to plants have a life cycle in which either: 1) the newly hatched insect differs from the fully grown adult primarily only in size -- the young or nymphs look like the adults in form, except that the wings may not be developed, and they feed in the same places (see illustration below):



GRADUAL METAMORPHOSIS

Insects with gradual metamorphosis change shape gradually. Wings develop externally and as growth takes place, the nymphs look more like the adult

or 2) the adults and young are not alike -- the young or immature forms are wormlike, usually called larvae or caterpillars, while the adults are moths, butterflies, flies or beetles (See illustration). The damaging stages of insects with this type of life cycle are most often the larvae which may be found when the adult stage cannot. Many times insects found on injured plants are not the primary cause of the injury, they just happened to be there.



COMPLETE METAMORPHOSIS

Insects with complete metamorphosis go through four stages of growth. None of the young looks like the adult. There is a great change in shape when the adult emerges from the pupal stage.

Ways Insects Injure Plants

a. Chewing: Insects with chewing mouthparts usually leave obvious feeding wounds such as notched leaves, tunnels or wounds in wood, bark, roots, stems, fruit, and seeds, or mining in the leaves. Symptoms: ragged leaves, holes in wood and bark or in fruit and seed, serpentine mines or blotches in leaves, wilted or dead plants, or presence of "worms".

b. Sucking: Some insects with sucking mouthparts may not leave obvious feeding wounds since they puncture the leaf or fruit to suck out the sap and cell contents, and to inject toxins into the plant. Symptoms: leaves usually off-color, evidence of scorch or hopper burn, wilted or misshapen foliage and fruit.

c. Oviposition: Scars can be formed on stems, twigs, bark, or fruit as a result of injury during egg laying. When certain insects have laid eggs in parts of plants, galls may form as the young insects develop. Galls are growths that resemble tumors and may form on leaves, twigs, buds, and roots. They disfigure plants and some may cause serious damage.

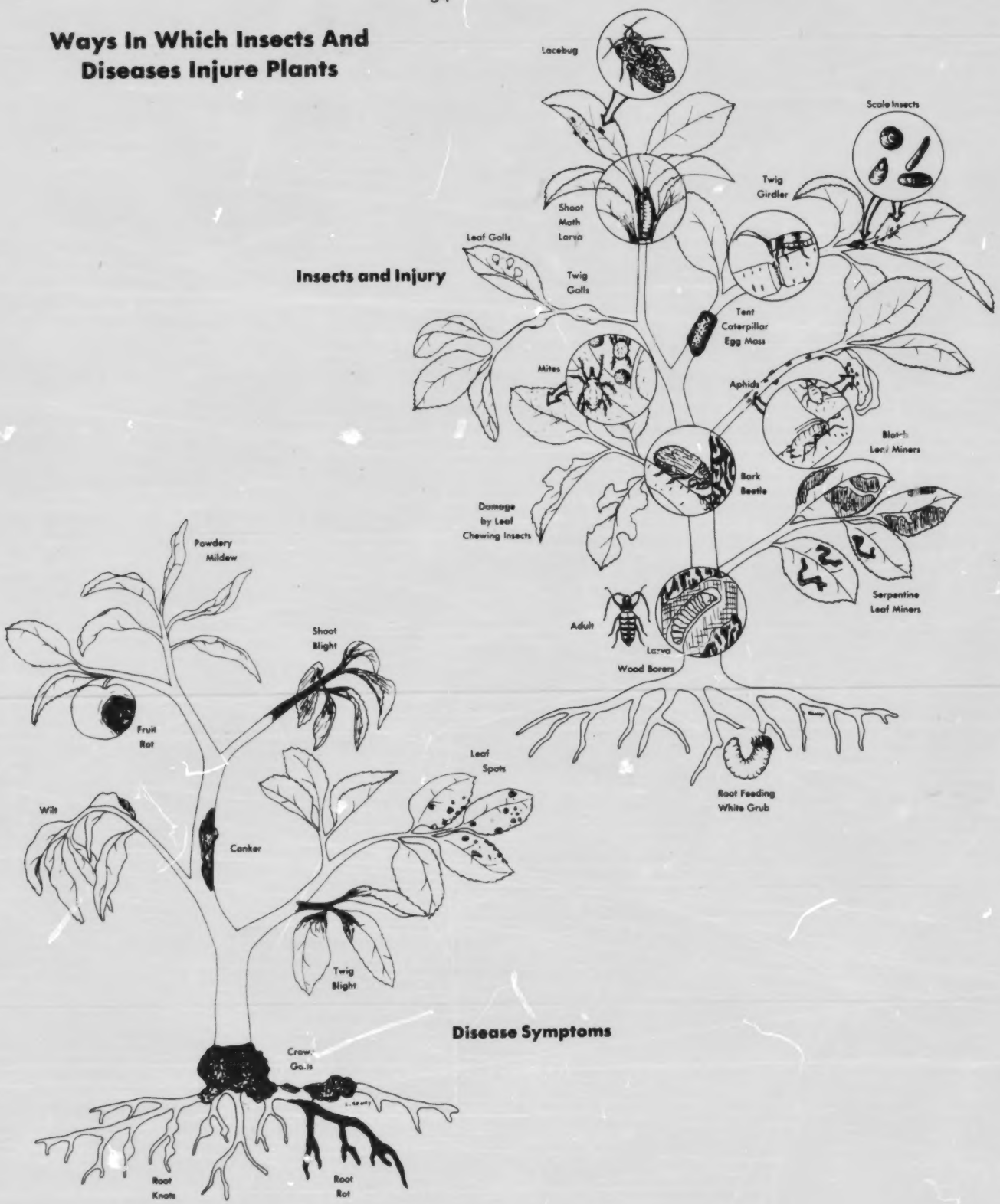
d. Vectors of diseases: Insects may carry plant pathogens on their body or inject them with the mouthparts while feeding from plant to plant, e.g., elm bark beetle - Dutch elm disease; various aphids -- virus diseases; bees -- fire blight. Symptoms: leaves wilted, dwarfed, foliage off-color.

e. Excretions: Honeydew deposits secreted by some insects lead to the growth of sooty mold (a black fungus), and the leaves are unable to perform their manufacturing functions. This results in a weakened plant. Symptoms: sooty black areas on leaves, twigs, branches, and fruit.

2. Diseases

Unlike insects you cannot always see the organism which causes the disease. You can see the signs and symptoms of its presence but in the early stages these may be difficult to identify. Some diseases are caused by non-living agents such as air pollution, drought, etc., and are called non-infectious plant diseases. Living causal agents are called pathogens and cause infectious plant diseases. Sometimes they can be easily recognized with the naked eye. However, in most instances you cannot see the pathogen without the use of a microscope. You see only the symptoms. Knowledge of the host plant, its diseases, and signs or symptoms are very important in identifying them in the field. Prevention of further spread of a disease is a primary concern. Once infection occurs, favorable moisture (rain, dew, etc.) and temperature conditions may cause rapid spread and damage. Leaf spots and shoot

Ways In Which Insects And Diseases Injure Plants



blight may spread very quickly under favorable conditions, while wilts and root rot diseases may spread more slowly. Early and accurate diagnosis is vital to successful control.

Ways in Which Infectious Diseases Damage Plants

a. Disrupt water-conducting cells and plug the vascular system which conduct food and water throughout the plant. Symptoms: yellowing, wilting, dead branches.

b. Destroy or damage cells of leaves and sometimes fruit. Symptoms; blotch, scab, black spots on leaves, fruit rot.

c. Destroy or damage roots and root hairs. Symptoms: wilting, yellowing or stunting of plants, rotted roots, death.

d. Cause formation of galls and overgrowths. Symptoms: unusual growths on flowers, twigs, and roots.

e. Decay of wood.

f. Damage to flowers, fruit and seeds causing them to rot. Examples: fireblight, bacterial rot of potato.

g. Damage or death of plant tissues from production of toxins.

3. Nematodes

Nematodes are very small roundworm-like animals, whose young resemble the adult except for their smaller size. Those which damage plants live in the soil and are round, thread- or eel-like worms which are so small that they can<u>NOT</u> be seen without the aid of a microscope. Many types of nematodes cause no damage, but others feed on or in the roots, bulbs or stems, or on the leaves or seeds of plants. Special training is necessary to identify them. Symptoms of disease caused by nematodes are usually localized in one or more spots in a field or turf area, but the nematodes involved must be isolated, identified, and numbers estimated before the symptoms can be accurately evaluated. An examination of plant roots and soil taken from around the roots can help determine whether nematodes are wholly or partially responsible for poor plant growth.

Ways in Which Nematodes Injure Plants

a. Mechanically disrupt water conductive tissues or induce cell abnormalities resulting in inefficient translocation of water and nutrients. Symptoms: wilt, loss of color, yellowing of leaves.

b. Destroy or damage roots and root hairs. Symptoms: stunted growth, poor vigor; roots with necrotic spots or dead root tips and/or stunted roots, or loss of feeder roots.

c. Causes gall formations on plant roots which will reduce vigor in the plant. Symptoms: root galls -- be careful not to confuse with nitrogen fixing nodules on legumes.

Nematode population levels for preplant treatments have limited meaning. Knowledge of their damage to previous crops is more useful. Usually the combination of one or more of the following factors are necessary to cause economic damage.

1. Optimum conditions for nematode build-up.
2. Plant stress conditions.
3. Nematode disease complexes.
4. Root or tuber quality (root crops).

The principle nematodes and crops of economic importance are as follows (there is considerable variation in species and host specificity):

Nematodes	Crops
Root-knot	A very wide economic host range (numerous species and specificity).
Root lesion	Most crops, but especially perennial crops.
Cyst	Sugar beets, crucifers, soybeans, potatoes, cereals, rice (species and strain specific)
Citrus	Grape
Ring	Primarily perennials
Dagger	Primarily perennials
Sting	Corn, sorghum, and grasses

For further information on specific nematode problems contact your local Cooperative Extension agent for the necessary information.

4. Weeds

Familiarity with two major groups of weeds, narrowleaved weeds and broadleaved weeds, is important in selecting the proper herbicide.

Narrowleaved weeds include all grasses, sedges (nutsedge), rushes, bulrush, cattails and many other plants. All have leaves with parallel veins and are easily recognized (monocots).

Broadleaved weeds is the larger group of the two and includes mustard, dock, smartweeds, pigweed, purslane, field bindweed, blackberries and many others. The veins in the leaves of this group are not parallel but are net-like (dicots).

Ways in Which Weeds Injure Plants or Affect Land Use

a. Reduce yields -- competition for moisture, light, nutrients.

b. Reduce crop quality -- weed seeds, dockage, weeds in hay, straw, etc.

c. Increase production costs -- additional tillage, cultivation of nursery crops; prolong precommercial period in plantations.

d. Increase labor and equipment costs -- machinery wear and tear, etc.

e. Insect and disease carriers or hosts -- e.g., wheat stem rust, corn borer, pine needle rust, and numerous viruses.

f. Poisonous or irritating to animals or people -- cocklebur seedlings, poison ivy, hay fever, etc.

Collecting Specimens for Identification

If you are unable to identify the pest or the damage from the information you have, you may have access to an authority who can come to the field to identify the damage or pest. If this is not possible, you may wish to collect a sample to send him. No matter how much experience you have had, some problems will require further investigation and you will want to collect specimens. Directions for sampling and shipping are available from your local Cooperative Extension agent.

Economic Considerations

Economic injury levels depend on the amount of damage that can be tolerated rather than on pest population levels. In some instances the presence of

even a small pest population may result in too much damage, while in other cases extensive populations may not cause significant injury. Sometimes the pest is very conspicuous, but may not be affecting crop yield or quality. The number of pests that can be tolerated varies widely even for the same species in different areas on the same crop and at different stages of crop maturity. The presence of an insect is not necessarily an indication of economic threat to the crop. In fact, low numbers may be beneficial or necessary in maintaining the parasites, predators, or pathogens of the pest. In most situations, complete control or eradication of a pest is not necessary.

When damage to quality, yield, or longevity is threatened and other factors such as parasites, predators, weather, etc. will not prevent it, pesticides will be needed. This is often referred to as economic threshold or damage threshold. Economic threshold levels are not always available for a given crop, pest or locality. The decision to apply a pesticide or not is usually based on past experiences and knowledge of the costs or risks versus benefits to result from control. Costs of damage that will result without control must be weighed against the cost of control. In making this decision, one must consider the following questions:

1. Is the pest population approaching levels that may cause economic threshold damage?
2. Are natural controls (parasites, predators, weather, etc.) present and likely to reduce the population before economic loss results?
3. Will the costs of the pesticide and the labor needed to apply it be less than the gains to be made?
4. What effect will the pesticide have on the environment and the beneficial non-target animals?
5. Can the crop be harvested before damage is serious?

The dollar return from control should be greater than the cost of control. Example: Alfalfa can recover after sustaining substantial damage from the alfalfa weevil. Or, it can be harvested before serious damage results. But, a little patch of late blight in a field of potatoes or tomatoes is a warning of serious damage to follow. Any good commercial applicator should be able to advise his client and carry out the necessary control procedure. Example: The control procedure should result in production of a crop or preservation of

a forest stand where otherwise this would be lost. Most often there is no easy way to estimate cost benefit ratios in dollars. But you should at least be able to identify specific benefits that will result from control of a pest, so these may be weighed aginst cost plus any possible adverse effects of the procedure.

When damage becomes noticeable, the best timing for control procedures is usually already past; you may have to accept the damage that year and wait until the next to apply effective control measures.

Life Cycle

A thorough knowledge of the life cycle of the pest is important in making the decision as to whether or when to take control measures. Most, if not all, pests are most readily controlled at one particular stage in their development. The treatment for many pests must be applied before their damage is noticed. Example: most fungicides are protectants and must be on the plant or in the soil as a protective barrier before spores or mycelium of the pathogenic fungus contacts the plant. Most infection occurs under moist conditions. So, it is important to spray before rains come, not afterwards. Knowledge of the disease cycle is a key to proper application of preventative fungicides.

Preemergence sprays for weeds and preventative sprays for corn earworm based on egg observations, are other examples of the value of knowing life cycles. Once the earworm is in the ear it is difficult to kill and the damage is already done. Other pests may already be gone by the time their damage is noticed. Spraying is then a useless exercise and may harm beneficial forms. If you are not familiar with the life cycle or disease cycle and do not bother to look it up, you are not in a position to make the right judgements.

The proper control measure depends upon the biology of the insect, disease, or weed. If an insect is held partially in check by parasites, you may wish to use less pesticide for a slightly lower degree of control, so that the parasites will survive. For this reason, forest stands with low population of defoliating insect such as gypsy moth, and alfalfa fields with low populations of alfalfa weevil may be left untreated. In terms of disease, computerizing observations of temperature, rainfall, and relative humidity during the growing season has already led to an operational system for forecasting the occurrence of potato late blight. Fungicide sprays can be withheld or applied according

to this forecast which is based on the biology of the disease. In one area this system saved the cooperating growers four sprays in one season. Knowledge of this disease cycle then, has led to financial saving, larger yields, reduction of crop injury by equipment, better blight control with less storage losses, and an appreciation of the professionalism of the commercial applicator. Since most fungicides must be applied before the plant is infected (protectants) rather than after the plant is diseased (eradicants), a complete knowledge of the particular disease is necessary for effective control.

An understanding of the growth habits of weeds is also a requirement for making judgements about chemically treating with herbicides versus cultivation, rotation, or other such practices. Part of the weed population in a given field can often be controlled by cultivation, but weeds within seedbeds or surrounding planting spots often must be controlled by application of an herbicide.

Other Methods of Control

You should not fail to suggest supplemental cultural practices to your growers. One such practice is crop rotation. When a successful rotation program is followed, a pest specific to one crop will not carry over to the following crops. For example, potatoes should not be planted following sod if the white grub complex is present.

Sanitation practices such as cleaning up cull piles and plowing down old stubble are a definite help in eliminating overwintering or off-season sources of both insects and plant diseases.

The use of resistant varieties of food and feed crops can be practiced by everyone from the home gardener to the large agricultural producer. This concept has been followed for many years in the field of plant diseases. Now plant varieties resistant to insects are being produced, and experimental data is indicating varietal resistance of potatoes and tomatoes to weed competition. Most growers already tend to plant disease resistant varieties, since these are the ones commonly recommended and sold.

Such supplemental practices should not result in loss of business. There is plenty of work for competent commercial applicators; indeed many have problems meeting their obligations. But you can suggest ways in which your customers can aid in pest control, their businesses should be more efficient and profitable and your reputation and profits should grow with theirs.

III. PESTICIDE APPLICATION EQUIPMENT

Agriculture, Forestry, Ornamentals, Shade Trees and Turf

The equipment used in applying pesticides varies with the crop or other target, the type of application, the pest to be controlled and the formulation used. There are many different types, including granule spreaders, hydraulic sprayers, boom sprayers, airblast sprayers including mist blowers, soil fumigation machinery, and tarpaulin fumigation. They all have one requirement in common; they must apply the right amount of pesticide equally over the target area, and you must know at what rate they are applying. You know this as calibration.

Too little, uneven, or too much deposit are all inefficient use of material resulting in insufficient control, spotty control or excessive residue, respectively. Proper adjustment and calibration of the equipment can prevent needless waste of pesticide chemicals by depositing the required amount on the target.

The total deposit laid down on the target, excluding effects of drift or evaporation depends on:

-- The concentration of pesticide in the tank. When spraying with a single nozzle or gun to the point of runoff, this is the important consideration.

-- The rate of discharge.

-- The speed at which the equipment travels.

-- The area covered (the swath width on turf, field or row crops, the distance between rows for fruit trees, the size of shade trees).

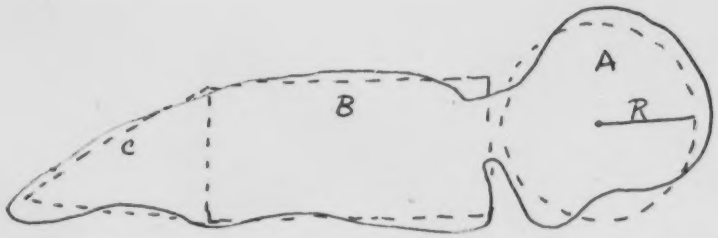
The total area (square feet) of rectangular or square areas to be treated can be determined by multiplying the width (W) by the length (L) of the area (W X L - area sq. ft.). Determining the area to be treated of irregular shaped areas such as golf greens is more difficult. One method is to determine the general shape of the area, then impose known shapes (circles,

triangles, rectangles, and squares) over segments of the area where appropriate (see example below). The area in each shape is determined and added to the rest to obtain the total area to be treated.

Area A is a circle

Area = 3.14 X R^2

(R = 1/2 diameter)



Area B is a rectangle

Area = L X W

Area C is a triangle

Area = 1/2 X B X H (Base X Height)

Most of you already have your application equipment and are familiar with its performance. However, if you are buying new equipment, you will want to get some that is properly set up for the bulk of the work you intend to do. You have several sources of information available -- your extension service, other private or commercial applicators experienced in the same work and manufacturers. The manufacturer can usually furnish rather complete performance data and you should take full advantage of any charts, calibration aids or other help that he can supply.

COMPONENTS OF PESTICIDE APPLICATION EQUIPMENT

Your core manual describes the principal types of pesticide application equipment. This section will describe some of the parts that make up application equipment of importance for use in agriculture, forestry, nursery, ornamentals, and turf. Determine your needs, then check manufacturers specifications to obtain the right equipment for the right job.

Tanks

The tank is a major component of a sprayer. It should be large enough to avoid the need for too frequent refilling. (If your nozzle discharge is 10 gpm, a 100-gallon tank will last only 10 minutes. But, too large a tank is wasteful if it is seldom filled).

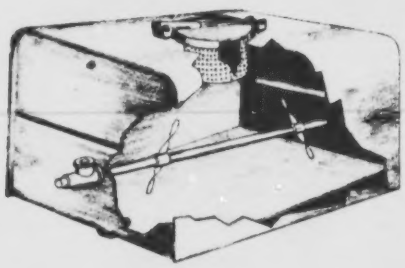
Stainless steel and fiberglass are considered the best tank materials because of their corrosion resistance, but they are expensive, so the buyer must weigh his need for durability against cost.

Every spray tank should have shut-off valves so that any liquid in the tank can be held there without leaking out of the pump, strainers, or other parts of the system which are serviced most frequently.

Agitators

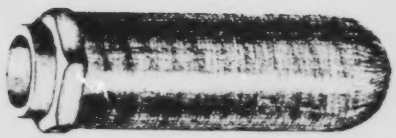
The need for agitation depends on the type of chemicals applied. Liquid concentrates, soluble powders, and emulsions (i.e., 2,4-D, malathion EC) require little agitation -- usually the flow from the by-pass hose is enough.

Wettable powder suspensions, however, require vigorous agitation to prevent settling out. Tanks with square corners require better agitation than tanks with rounded shapes.



There are two methods of agitating the spray material in the tank. Mechanical agitation, the most positive method, is provided by paddles or propeller. Hydraulic agitation is provided by the return flow of excess spray material from the pump. When hydraulic agitation is used to suspend wettable powders, a simple by-pass line from the relief valve is not enough. There should be a separate agitator line from the pressure side of the pump to the bottom of the tank.

Strainers



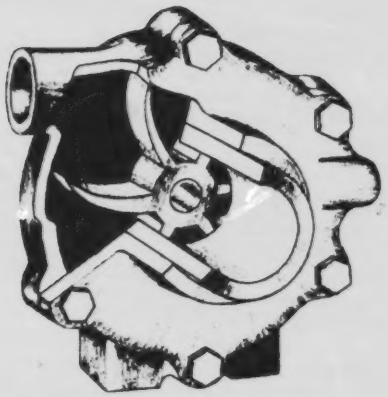
Strainers are used to prevent scale, rust flakes and other foreign material from plugging the nozzle or other working parts of your sprayer. They may be installed as necessary on the pressure line or may be purchased as a part of the nozzle and should also be placed on the intake line.

Pumps

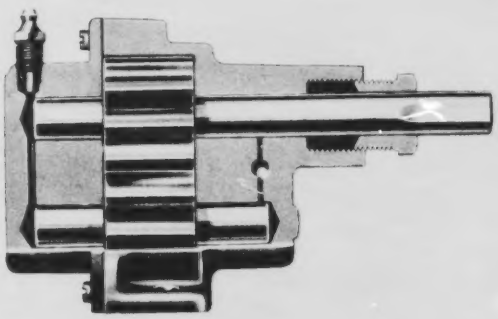
A good spray pump must deliver the required pressure and the required volume within its normal working capacity so it is not constantly working at its limit. If abrasive materials are used it must be able to pump them over a long period of time without much loss of performance. The metal parts must be resistant to corrosion if corrosive materials are to be used. You must choose gaskets, plunger cups and impellers that are resistant to swelling or chemical breakdown when using most liquid pesticides. If wettable powders are used the pump must be abrasion resistant.

Never operate a sprayer pump at speeds or pressures above those recommended by the manufacturer. The pump will usually take this stress for a short time, but will soon break down or wear out. Never run pumps dry since they depend on the spray liquid for lubrication. Some spraying applications require only simple economical pumps. Generally speaking, as your pressure and volume requirements increase, the cost and complexity of a satisfactory pump also increases.

Centrifugal sprayer pumps use an impeller to give high volumes at low pressures, although two stage centrifugal pumps now used on some orchard and vegetable sprayers develop pressures in excess of 200 psi. The power requirement is relatively low and the operating speed is relatively high. They are the only sprayer pumps in general use that are not positive displacement pumps so pressure regulators or release valves are not essential. Pressure depends on RPM of the pumps. Because the impeller does not contact the pump housing, most centrifugal pumps are satisfactory for pumping abrasive mixtures such as wettable powder suspensions even when they are concentrated. Centrifugal pumps are not self priming so they must be mounted below the tank outlet or a priming system must be built in. They are relatively cheap, but are entirely satisfactory for many types of application.

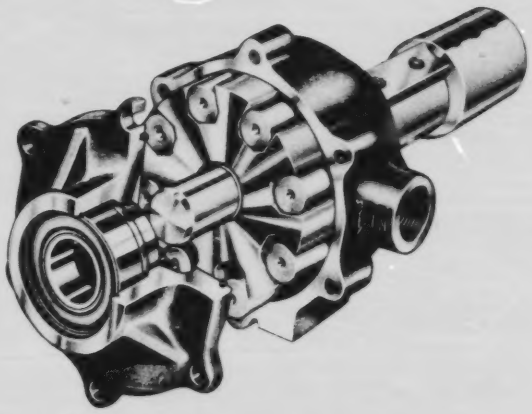


Gear pumps are simple, low priced positive displacement pumps that are used on agricultural sprayers for operating pressures of up to 100 pounds. They are satisfactory for pumping liquids or emulsions, but wear rapidly if suspensions are used. They are self priming when in good condition, but may

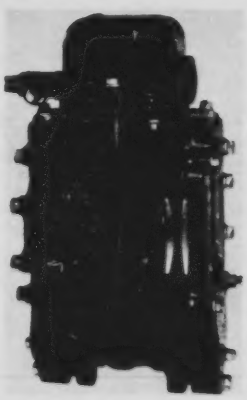


lose that ability when worn. Depending on size, they deliver low to moderate volumes of liquid. They are not affected by solvents since all the parts are metal. Some are cast iron with stainless steel impellers; others are bronze so they will resist corrosion. They are commonly used on mist blowers and boom sprayers. Their power requirement is more than for centrifugal pumps, but is still relatively low. When a gear pump becomes worn it usually cannot be satisfactorily rebuilt.

Roller pumps are commonly used on low pressure and boom type sprayers. They are positive displacement self priming pumps with a slightly higher power requirement than gear pumps. They are also generally more costly but still relatively inexpensive. The rollers, made of nylon or rubber, are more abrasion resistant than the gears in gear pumps and can be replaced when worn or swollen. However, suspensions will wear the rest of the pump out after awhile. Roller pumps are capable of higher pressures than the gear pumps that are used on sprayers but sustained operation at maximum pressures will often cause the seals to blow out.

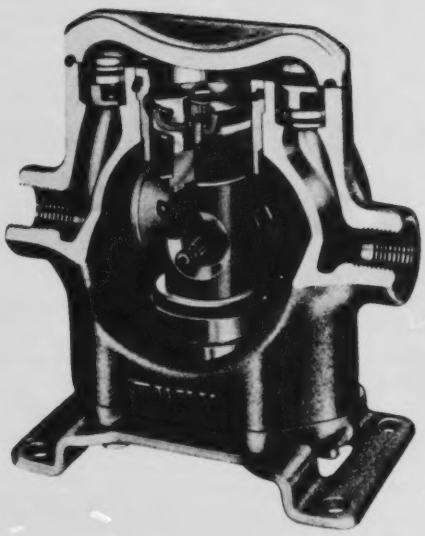


Diaphragm pumps are similar to gear and roller pumps in volume and pressure characteristics. Since the spray mixture does not come in contact with any moving metal parts except the valve assembly, these pumps are extremely abrasion resistant. The



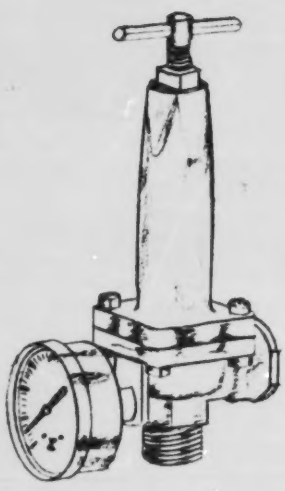
neoprene diaphragm may be injured by some solvents. Where volume or pressure requirements are not high these pumps are probably the best choice for abrasive spray suspensions.

Well made piston pumps are probably the most reliable of the commonly used sprayer pumps. They are heavily built and the larger ones are capable of pressures of 600 lbs/sq. in. or more. They deliver moderate to high volume depending on the pump capacity. The better quality pumps have replaceable plunger cups made of leather, neoprene or nylon fabric so they are abrasion resistant, easily rebuilt and capable of handling wettable powder suspensions year after year. The power requirement is higher than the other pumps. For low pressure sprayers a piston pump is not usually needed, but they are excellent where higher pressures are required or where both low and high pressures are needed.



Pressure Regulators

A pressure regulator is one of the most important parts of a sprayer. The pressure regulator controls the pressure and therefore the quantity of spray material delivered by the nozzles. It protects pump seals, hoses, and other sprayer parts from damage due to excessive pressure



and by-passes the excess spray material back to the tank.

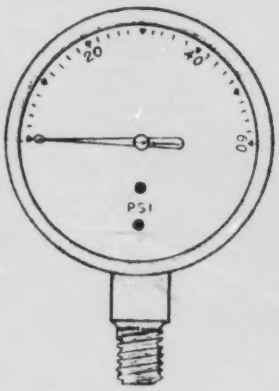
There are two types of pressure regulators, simple relief valves and pressure unloaders. The relief valves are simple by-pass valves that require the pump and engine to keep working just as though one were spraying, whereas the unloaders maintain working pressure on the discharge end of the system but move the overflow back into the tank at lower pressure, thus reducing strain on the engine and pump.

In the past almost all high pressure hydraulic sprayers were equipped with unloaders, but now, probably as an economy move, the trend is toward relief valves. There is no substitute for a spring-loaded pressure regulator.

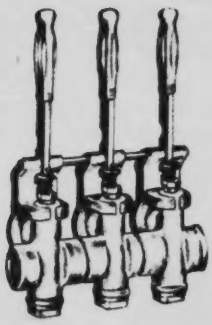
When selecting a pressure regulator, be certain that the flow capacity of the regulator matches that of the pump being used.

Pressure Gauge

A pressure gauge is essential on any sprayer. Without one, the operator cannot tell how the sprayer is functioning. If the pressure does not remain constant, the amount of liquid coming out of the nozzles will vary. The gauge should always be mounted so that the operator can see it easily. Pressure gauges often wear out soon because they become clogged with solid particles of spray material. A glycerine loaded diaphragm type gauge is more expensive, but will last indefinitely.



Selector and Shut-Off Valves



The selector and shut-off valve allows the operator to conveniently select one to three sections of the boom for spraying a narrow strip in the field, or to shut off all sections of the boom quickly and easily at the end of the field.

Hoses

There are four main points to consider in selecting sprayer hoses:

1) Composition (chief liner material)
2) Construction (reinforcement, rigidity or flexibility)
3) Working pressure
4) Size

High quality hoses and fittings are expensive but economical when used over a long period of time. The hose liner should be resistant to chemical action of the spray materials. The working pressure of the hose should be equal to the maximum pressure the pump delivers. If the hose is too small (inside diameter) the sprayer will not operate properly. If the hose in the suction line is too small the pump will starve. If the hose in the pressure line is too small there will be excessive pressure and drop in volume.

PESTICIDE EQUIPMENT

Depending on the crop being grown the following are examples of specific equipment for proper pest control. You will be responsible for knowledge of the equipment that is commonly used in your commercial category or subcategory.

Agricultural

1) Plant

Multipurpose sprayers

-- Low and high pressure boom sprayers

.. low - field and forage, vegetable

.. high - vegetables, small fruit

-- High pressure sprayers (hand gun and hose)

.. Tree fruit, brush control, Christmas trees

Airblast

.. Tree fruit, small fruit, vineyard, vegetable, Christmas trees

Granular

.. Vegetables, small fruit, field crops, Christmas trees

Soil fumigation

.. Tree fruit, small fruit, vegetables

Aerial

.. Vegetables, tree fruit, small fruit, field and forage, vineyards, Christmas trees

Forestry

Aerial

.. Forests

Mist blower

.. Forest nurseries, forest seed producing areas

High pressure (hydraulic) sprayer

.. Forest nurseries, forest seed producing areas

Ornamentals and Turf

1) Arborist

High pressure (hydraulic) sprayer

Mist blower (airblast)

Injectors

2) Landscapers

Multipurpose sprayers

-- High pressure sprayers (hand gun and hose)

.. Trees, shrubs, vines, turfgrass

.. Vines and turfgrass

Mist Blowers

.. Trees, shrubs, vines

Granulars

.. Trees, shrubs, turfgrass

Soil Fumigation

.. Turfgrass

Injector

.. Trees

3) Nurserymen

Multipurpose sprayers

-- High pressure sprayers (hand gun and hose)

.. Propagation house

.. Nursery blocks and fields

Mist blower

.. Propagation house

.. Nursery seedling beds

.. Nursery blocks and fields

Granular

.. Nursery seedling beds

.. Nursery blocks and field

Soil Fungicides

.. Nursery seedling bed

Aerial

.. Nursery field

4) Turf Managers

Multipurpose Sprayers

-- Low and high pressure boom sprayers

.. Low - golf course fairways, other turfgrass areas

.. High - golf course fairways, other turfgrass areas

-- High pressure sprayers (hand gun and hose)

.. Trees, shrubs, greens, lawns (school grounds, parks, industrial grounds, etc.)

Aerial

.. Golf course fairways, parks

Granular

.. Golf course fairways and greens, lawns (school grounds, parks, industrial grounds, etc.)

Soil Fumigation

.. Golf course greens

Multipurpose Sprayers

Agricultural (plant), Ornamentals and Turf, (Arborists, Landscapers, Nurserymen and Turf Managers)

Multipurpose sprayers are designed to handle most spraying needs from low-pressure weed or row-crop spraying (30 to 50 pounds) up to higher pressure fruit tree and field-crop spraying (200 to 400 pounds or more).

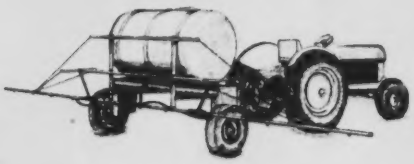
The sprayers have plunger- or piston-type pumps that deliver 3 to 8 gallons per minute at pressures up to 800 pounds. Tanks range in size from 50 to 800 gallons. The spray material is mechanically agitated.

Skid-mounted models are powered by an auxiliary engine. Wheel-mounted models may be powered by an auxiliary engine or by the tractor's power take-off.

Hand gun and hose are standard equipment; field booms, usually 20 to 35 feet in length, are available as optional equipment.

Boom Sprayers-Low Pressure and High Pressure

Agricultural (plant), Ornamentals and Turf (Turf Managers)



Sprayer booms are commercially available in lengths of 15 to 60 feet. The most common boom length is between 20 and 35 feet. Even with a 20-foot boom, it is essential to have some means of protecting the boom from damage if a tree or other obstacle is encountered. The most common boom is made in three sections -- one rigid section in the middle of the machine and a folding section extending out on each side. These outer sections are hinged at their inner ends and are supported from the center of the machine by a rope or light chain. This type of construction gives a 20- to 35-foot boom adequate support, and provides the versatility necessary in irregularly shaped areas and the mobility required when moving the sprayer through narrow gateways.

The height of the sprayer boom must be easily adjustable so the nozzles can deliver the chemical uniformly. Boom supports should be made so the boom can be set at any height from 12 to 48 inches above the surface being sprayed.

Your core manual describes low pressure field sprayers and high pressure (hydraulic) sprayers. While they differ somewhat in performance characteristics, both are used as agricultural and turf boom sprayers. The methods for calibration apply to both types of sprayer.

Boomless sprayers have a central nozzle or nozzles that are designed to produce a very wide spray pattern resulting in a wide swath similar to that laid down by a boom type sprayer. They may be calibrated by spraying a known acreage with water and refilling as described in your core manual.

There are four variables that you can adjust to govern the amount of spray delivered by boom sprayers. These are:

-- nozzle spacing on the boom

-- nozzle tip orifice size

-- pressure

-- ground speed of the sprayer

Usually your equipment will already be set up to meet your local needs, so you will make minor changes in spray delivery by changing the speed and/or pressure, and major changes by using larger or smaller nozzle tips. Routine checks of your sprayer should be made to make sure that the nozzles are not badly worn and have uniform output, uniform appearance of spray pattern and equal fan angle. Replace any nozzle tips having a flow of 10% more or less than required or having obviously different fan angles or patterns.

Nozzle Bodies

A complete nozzle assembly consists of the body, screen, cap, and tip or orifice plate. The function of the nozzle body is to attach the screen and tip to the boom. Several different nozzle body designs are available. All designs perform adequately, but each design has advantages for specific spraying jobs.

Nozzle Tips

A nozzle is an atomizing device that spreads the liquid droplets in a definite direction to form the spray pattern. Nozzles are made to accommodate a variety of replaceable tips or discs to meet different spraying requirements. Manufacturers of sprayer nozzles can supply data sheets for the delivery rate (usually in gal/min at different pressures for their nozzles). The application rate CANNOT be specified on these data sheets unless the forward speed of the sprayer and the spraying pressure are specified.

WARNING -- Never operate nozzles at high pressures to compensate for selecting the wrong nozzle size. Unnecessarily high pressures increase the rate of nozzle wear and increase the drift hazard.

Nozzle tips and discs are made of aluminum, brass, ceramic, plastic, stainless steel, or tungsten carbide. Tungsten carbide discs and stainless steel tips are more resistant to abrasive wettable powders, but they are more expensive than steel discs and brass tips. No single material is the least expensive, most corrosion resistant, and most durable for spraying all agricultural chemicals.

Nozzles are classified according to the spray pattern as (1) fan or flat pattern, (2) broadcast or boomless, (3) flooding fan, and (4) full cone or hollow cone.

Flat Fan—There are three types of flat fan nozzles:

The regular flat fan nozzle makes a narrow oval pattern with lighter edges. It is used for broadcast spraying. This pattern is designed to be used on a boom and to be overlapped 30–50 percent for even distribution.

Fan or Flat Pattern Nozzles

The spray droplets are arranged in a fan shape as they leave the nozzle. The orifice (opening) in this type of nozzle is elliptical. Herbicides are best applied with this type of nozzle because:

1) when a series of these nozzles is properly mounted on a boom, the spray material is more evenly distributed than it would be with any other type of nozzle; and

2) at 30 to 60 psi, the flat-pattern nozzle delivers small to medium droplets that do not drift excessively.

The most commonly used flat-pattern nozzles have a spray angle of 65, 73, or 80 degrees; the most commonly used pressure is 40 psi.

For most herbicide spraying done with a relatively short boom (20 to 35 feet), the 80-degree flat-pattern nozzle is best. It is possible to keep the boom relatively low to reduce the drift hazard, and give a uniform distribution of spray material over the entire length of the boom.

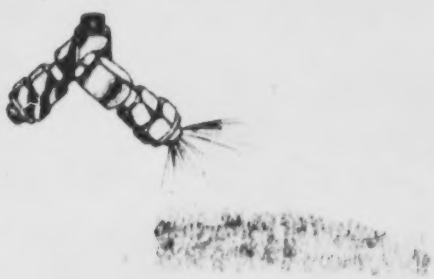
Special flat-pattern nozzles, usually called even-spray nozzles, are available for band spraying row crops. If a uniform distribution of herbicides is required, these nozzles should not be used.

The flat-pattern nozzle is available in brass, plastic, stainless steel, and hardened stainless steel. The brass nozzle is inexpensive and satisfactory for spraying chemicals in solution. It is not durable enough to spray any more than 20 acres with atrazine. The plastic nozzle is corrosion resistant but should not be used to spray more than 60 acres with atrazine. The stainless steel nozzle is corrosion resistant and durable but should not be used if more than 200 acres are sprayed with atrazine. The hardened stainless steel nozzle is the most durable, but it is not as corrosion resistant.

NOTE -- When using any wettable powders, it is essential to calibrate the sprayer frequently, because as a nozzle wears, the quantity of spray material delivered INCREASES.

Broadcast or Boomless Nozzle

The broadcast nozzle is made of one or more nozzles in a cluster. These nozzles deliver a flat fan-like pattern that covers a swath up to 70 feet wide. The spray droplets range in size from very small to very large. Broadcast nozzles are convenient for spraying areas in which a uniform distribution of spray material is not essential.

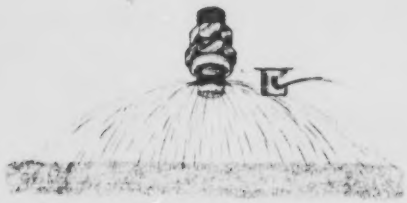


Broadcast—This nozzle forms a wide flat fan pattern. It is used on boomless sprayers and to extend the effective swath width when attached to the end of a boom.

CAUTION: Never use a broadcast type of nozzle when there is any breeze. Severe drifting and crop damage may result.

Flooding fan

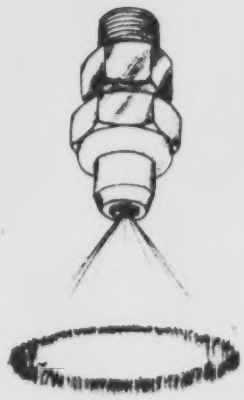
This is a broadcast-type nozzle that has been modified to be mounted on a boom. The nozzle spacing usually used is 40 to 80 inches. The small- to large-sized spray droplets are not distributed as uniformly as the droplets from a flat-pattern nozzle. The flooding-fan nozzle is available in brass or stainless steel. Its main use is for surface application of herbicides that are immediately incorporated into the soil.



The flooding nozzle makes a wide-angle flat spray pattern. It works at lower pressures than the other flat fan nozzles. Its pattern is fairly uniform across its width. It is used for broadcast spraying.

Full Cone or Hollow Cone

These two types of nozzles deliver circular patterns. The hollow-cone nozzle delivers most of the material to the circumference of the circle; the full-cone nozzle delivers liquid droplets to the entire area of the circle. The circular opening in the stainless steel, hardened stainless steel, or tungsten carbide disc



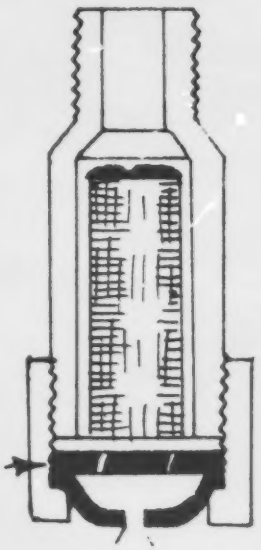
Hollow Cone—There are two types of hollow cone nozzles:

- the core and disk, and
- the whirl chamber.

The pattern is circular with tapered edges and little or no spray in the center. It is used for spraying foliage.

resists the abrasive action of wettable powders relatively well. The droplets are small or very small and not distributed uniformly when the nozzles are mounted on a boom. The major use of these nozzles is in the application of insecticides or fungicides to field crops where complete coverage of the leaf surfaces is extremely important and where spray drift is relatively unimportant. In cone nozzles the number of holes in the whirl plate affects the discharge rate. Be sure to check the whirl plate as well as the nozzle tips in calibrating a sprayer.

Nozzle Screens



The screen is placed behind the nozzle tip and in the nozzle body to help eliminate, or at least reduce, the frequency with which the nozzle orifice becomes plugged. The size of the nozzle opening and/or the type of chemical being sprayed dictate the size and type of nozzle screen that should be used. For most general herbicide spraying, a 100-mesh monel or stainless steel nozzle screen can be used. When wettable powder suspensions are being applied, a 50-mesh monel or stainless steel nozzle screen should be used.

When the boom must be turned off frequently -- in small fields or when the crop may be damaged by an overdose of chemical -- nozzle "dribble" may be a serious problem. A nozzle screen with a check valve in it will help eliminate dribble and will not affect the operation of the sprayer. Some care must be taken to make certain that the ball bearing does not become glued to its seat or that dirt or chemical particles do not hold the ball bearing off its seat.

Calibration of Boom Sprayers

There are several ways to calibrate boom type field sprayers. Your core manual gives you the method that is probably the simplest, but it also takes time because it requires spraying a measured acre with water. Another method involves timing the discharge rate of the sprayer over part of an acre and doing simple calculations. Neither of these methods cause variation in flow across the boom to be considered or corrected. Calibration jars that indicate rates of application over a given distance may be purchased.

High Pressure Sprayers (Hydraulic), Hand Gun and Hose

Agricultural (Plant), Forestry, Ornamental and Turf (Arborist, Landscapers, Nurserymen, and Turf Managers)

These machines are commonly used in turf, ornamental and shade tree spraying as well as for orchards and as boom sprayers for heavily foliaged vegetable crops. Usually they have piston pumps and mechanical agitators and are solidly built, long-lasting machines.

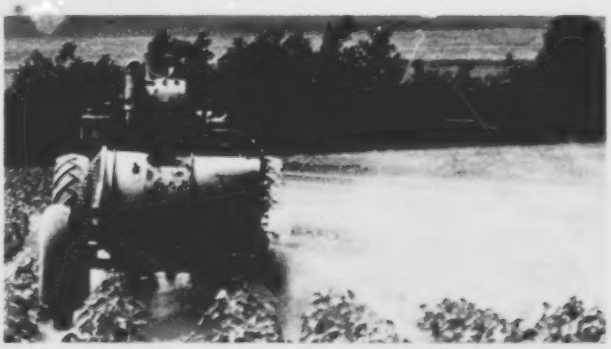
Usually high pressure hose and a hand-held spray gun are used when treating foundation plantings and other ornamentals, shade trees or nursery blocks, but a spray boom may be used when applying turf insecticides or fungicides.

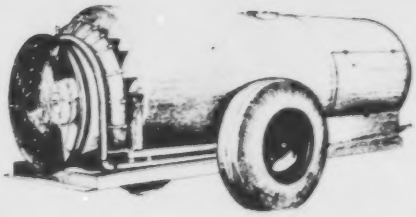
Foundation plantings, nurseries and turf can be treated with hydraulic sprayers of moderate pumping capacity such as 6 to 10 gpm at 400 - 500 psi.

Tall shade trees require high pressure, high volume pumps capable of 35 - 60 gpm at 650 psi. Spray mixtures used for ornamentals and shade trees are dilute, either suspensions or emulsions and the proper concentration of spray as mixed in the tank is applied to the point of runoff. Consequently, the sprayer does not have to be calibrated as long as it is big enough to adequately cover the target. When a boom is used for treating turf, the sprayer can be calibrated according to methods given in your core manual.

Airblast Sprayers

Agricultural (Plant)





Airblast sprayers are now in general use for treating tree fruits and are increasing in use for the spraying of row and field crops. (Mist blowers, a type of airblast sprayer, are used on shade trees and ornamentals.) They may be used to apply sprays ranging from dilute to highly concentrated. All use air to transport pesticides to the crop. Most use nozzles under pressure to provide initial breakup of the liquid, but some rely on airblast to shear the liquid into fine droplets. The volume and velocity of the airstream and the shape and arrangement of the air outlets vary depending on the purpose for which the machine was designed. It is essential that the airblast be sufficient to distribute the spray droplets throughout the swath to be covered.

Airblast machines for treating fruit trees are classified as follows:

1. Dilute spray (high gallonage) 301 or more gallons per acre.
2. Semi-concentrate (moderate gallonage) 101 to 300 gallons per acre.
3. Concentrate (low gallonage) 20 to 100 gallons per acre.
4. High concentrate (very low gallonage) 1 to 19 gallons per acre.

*5. Ultra high concentrate (ultra low volume) less than 1 gallon per acre.

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*Not satisfactory for treating fruit crops at present.

Many machines may be modified to make applications in more than one classification. However, because of airblast and pump limitations, machines designed for low volume usually cannot be used for applying dilute sprays. Likewise, high volume machines are not efficient for use in applying low volume since the airblast and pump capacities would be excessive.

The principles for adjusting and calibrating airblast machines for treating fruit trees are the same regardless of the volume of water to be used.

Calibration Procedures (Trees)

1. Make sure that the fan and pump are operating at speed indicated in the operator's manual and that all strainers, nozzles and similar equipment are clean and in good condition.
2. Check the liquid pressure at the nozzle position on the discharge manifold. Pressures must be within limits set in your operator's manual and/or nozzle performance table.
3. Determine the effective airblast. Effective airblast is that part of the airblast actually used in covering the trees in question.
4. Make a diagram of the air outlet and liquid manifold. Indicate the effective airblast, nozzle positions and upper one-third of effective airblast.

5. Determine:

   a. Gallons per acre to be applied

   b. Distance between rows

   c. Speed at which the sprayer is to be operated

6. Use a calibration slide rule provided by the manufacturer or the formula given below to calculate gallons to be discharged from one side of the machine.

   Gal/min (per side) =

$$\frac{\text{gals/acre X miles per hour (mph) X distance between rows (ft)}}{1000}$$

   For example, if one selects 200 gals/acre and 2 mph in an orchard with 25 ft. row spacing:

$$10 \text{ gals/min} = \frac{200 \text{ X } 2 \text{ X } 25}{1000}$$

7. Divide gals/min per side by 3. In the case cited above this would mean $10 \div 3 = 3.33$. Two-thirds of this volume or 6.7 gals. should be discharged through the upper 1/3 of the effective airblast and 1/3 of the volume or 3.3 gallons should be discharged through the lower two-thirds.

   Now consult a manufacturer's chart which matches the nozzles and nozzle pressure which you are using and select the appropriate sizes to give the desired rate of delivery for each position on the manifold. Spray coverage will be more satisfactory if nozzle sizes are selected which will give a gradual decrease in volume from the top to the bottom of the effective airblast, still maintaining the pattern of 2/3 of the liquid being discharged in the upper 1/3 of the airstream.

8. Install the desired nozzles in their appropriate positions. Unused nozzle positions above the effective airblast should be shut off but may be fitted with intermediate size nozzles for use during poor spraying conditions or for covering trees larger than those for which the sprayer was calibrated.

9. Fill the tank at least 1/4 full. Turn on the newly nozzled side and check the time it takes to empty the tank. Calculate the gallons discharged per minute. The example given in Step 6 indicated 10 gallons per minute as the desired delivery rate. At this rate the tank should empty in 5 minutes if 1/4 full is 50 gallons. Your allowable error should not be greater than 5% or 15 seconds. This means that a range from 4 minutes, 45 seconds to 5 minutes and 15 seconds is within desired limits. If the delivery rate falls within this range, nozzle up the other side and go to work. If not, go back over your calculations to find the error. If there is no error in your calculations the problem may be a faulty pressure gauge, wrong nozzle size, or obstructions that may have developed in strainers or other parts of the liquid system.

Most of the effort to calibrate and adjust a sprayer is lost unless it is operated at the right speed. Travel speed may be checked with a special speedometer, an engine tachometer (if proper adjustment is made for tire slippage) or by finding the number of trees you should pass per minute at the desired mph. Use the formula:

$$\text{trees passed/min} = \frac{\text{mph X 88*}}{\text{tree spacing in feet}}$$

*1 mph - 88 feet per minute

If your trees are planted 25 feet apart and you plan to travel at 2 mph, then using the above formula you should spray 7 trees per minute.

$$7 \text{ trees/min} = \frac{2 \text{ X } 88}{25}$$

If you are spraying more than 7 you are traveling too fast; less than 7, too slow. Adjust your speed accordingly.

After the newly calibrated sprayer is operating satisfactorily periodic maintenance checks should be made to assure continued high performance. This should include checking the engine or PTO rpm, wear on the nozzles, strainers, pressure, and possible partial clogging of pipes and/or the hose lines and nozzles.

Calibration (Row Crops)

Airblast sprayers for treating row and field crops should be calibrated using the same general procedure followed for those used to treat fruit trees. Slight variations in the procedure are as follows:

1. The swath width in row crop spraying is the distance between passes made across the field. The formula to calculate gallons to be discharged from one side of the machine then becomes:

$$\text{gals/min} = \frac{\text{gals/acre X mph X swath width in feet}}{500}$$

2. The most effective liquid discharge pattern within the airstream varies from one machine to another. In most cases it is necessary to discharge a large part of the liquid in the upper part of the airstream to assure proper deposits at the more distant parts of the swath. See manufacturer's operation manual for suggested nozzle sizes and arrangement.

3. You can check your speed by measuring the distance your sprayer travels in one minute and dividing by 88 (feet per minute traveled at one mph). Suppose you travel 176 feet in one minute:

$$2 \text{ mph} = 176 \div 88$$

Mist Blowers

Forestry, Ornamental and Turf (Arborist, Landscapers, Nurserymen, Turf Managers

Mistblowers are airblast sprayers that are economical and effective for use against many pests of ornamentals and shade trees. They vary in size from small back pack blowers which are powered by 2 cycle engines that move a few hundred cubic feet of air per minute (cfm) at velocities up to 200 mph to large truck or trailer mounted machines that move up to 60,000 cfm at velocities near 100 mph. They may have single or multiple nozzles that inject the pesticide into a single air outlet. Usually the back pack models depend on the shearing effect of the airblast to break the pesticide into fine, mist-like droplets. Larger mist blowers may pump liquid under varying pressures through nozzles to initiate breakup, but these models also depend on the airblast for final breakup into fine droplets.

Since mistblowers are dependent on a column of air to carry the pesticide to the tops of tall shade trees they must be operated in little or no wind. Under good conditions there is no difficulty in reaching the tops of

the tallest trees. However, operations should cease when the wind exceeds 4 - 5 mph. Otherwise, not only will it be difficult to reach tree tops, but excessive drift of pesticide will also result.

Emulsions are commonly used in mistblowers although wettable powders can be used. Some pesticides are available only as wettable powders or flowables. Usually relatively high concentrations of pesticides are used in mistblowers; a rule of thumb being 30 X dilute concentrations. One or two quarts of concentrate is often sufficient for a large tree. The insect pests best controlled by mistblowers are those that move to some degree, i.e., cankerworms and other worms and caterpillars, leaf beetles, lace bugs, etc. Pests such as mites, scales and fungi can be controlled but it is advisable to lower the concentration and increase the gallonage per tree accordingly.

Mistblowers are advantageous over hydraulic sprayers in that they are lighter in weight, use far less water and are physically easier to operate.

Calibration

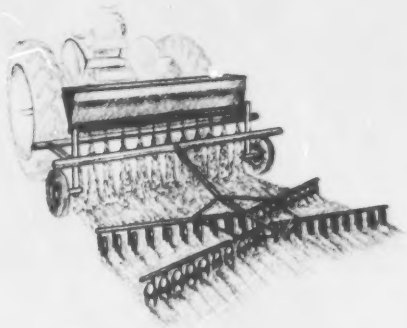
Mistblowers must be calibrated before using on ornamentals and shade trees. You do not apply pesticides in high concentration to the point of runoff as you do with hydraulic sprayers. In fact, it is difficult to see the usual mistblower deposit. Consequently, it is very easy to overdose. You must know the amount per minute of pesticide that your blower is delivering to the target and then time your application so that the right amount of spray concentrate is applied. Larger mistblowers are normally nozzled to deliver 1/2 to 2 gallons per minute (gpm). Thus, if a tree requires 2 quarts of 3% carbaryl spray and your blower delivers one gpm, you should treat the tree in 30 seconds. Your core manual tells you how to determine pumping rate, or as it is more properly called, delivery rate.

Sometimes it is necessary to apply a specified amount of pesticide per acre witha mistblower, for instance in treating nursery blocks or golf course fairways and greens. You can use the same procedure for calibration as is described for row crop calibration of airblast equipment.

Granular Application

Agricultural (Plant), Ornamentals and Turf
(Landscapers, Nurserymen, Turf Managers)

Granular pesticides must be applied with precision. Application of less than 90% of the label rate may result in ineffective control. Applications greater than recommended are costly and may be injurious to the crop. To meet these rigid requirements, spreaders must be carefully calibrated.



The amount of granules applied depends on the size of the metering opening, speed of travel, roughness of the field, and the flow rate of the granules. Granules flow at different rates, depending on size, density, and type of granule, temperature and humidity. Therefore, it is necessary to recalibrate your applicator for each different formulation.

Broadcast Applicators

These applicators may be of the full width hopper type with sliding gate openings or augers, or those using air, or spinning disks to cover swaths much wider than the machines.

With the full width sliding gate and auger types one should check the evenness of distribution from all the openings by setting the gate at a particular opening, turning the drive mechanism and comparing the output over a given time from each opening. Use the actual pesticide to be applied and a preliminary setting as recommended by the equipment operator's manual for the pounds per acre desired.

For the air and spinning disk types, select a preliminary setting as recommended by the operator's manual for the application rate desired. Select and determine your actual travel speed, then check the distribution pattern in the field. Containers deep enough to keep the granules from bouncing out should be placed on two foot centers across the swath at several intervals along the first pass. Then visually, volumetrically, or by weight compare the output at each station. This will alert you to any correction needed and allow you to select the best swath width.

To check the application rate, fill the hopper, settle the material in the hopper, then refill. Treat a known acreage using at least 10% of hopper contents and determine the pounds of granules required to refill. Then:

$$\text{pounds per acre} = \frac{\text{amount used (in pounds)}}{\text{acres covered}}$$

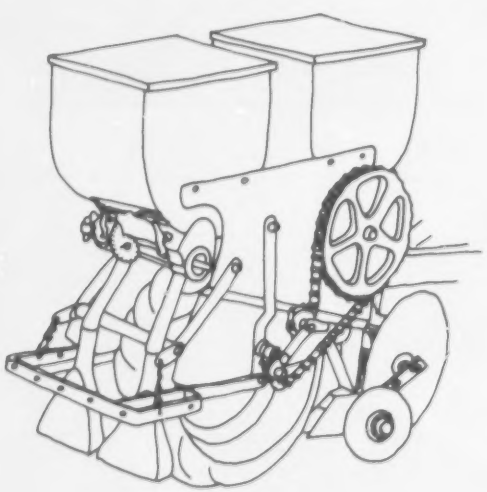
If the pounds per acre used is within 10% of that desired, treat another acreage and recheck the delivery rate, then make minor adjustments to correct the rate to within 5% and keep the delivery rate frequently rechecked during application.

If the amount used is more than 10% in error, then change the applicator's rate settings and recalibrate. Keep calibrating until the rate is correct to within 5%.

Remember most units require that speed be held almost constant to keep the application rate constant. Also weather conditions can markedly affect granular flow rates so be alert to such changes.

Band or Row Applicators

These applicators should have tubes to the spreader which are not too long nor too shallow. Some use a flexible metal hose to carry granules from the hopper to the ground. The hose must not be too long for even flow or the application rate will vary along



the row. Careful adjustment of the hose position or length may be necessary to provide uniform flow.

Banders should spread the band evenly even when on 10 to 15% slopes. Chain drives should use sprockets of 8 teeth or more to keep the drive speed uniform. Design should be such that the flow of granules stops when the drive stops even when the outlets remain open. The drive should be strong enough to turn and not break when restarted after road travel even when the hopper is full of granules.

Care must be taken to insure the placement of the granules over the row or in the row as the pesticide label directs. Proper placement in some cases is as important as proper calibration.

Band applicators should be calibrated in the field just like broadcast granular applicators, after first calibrating in a manner similar to row or directed sprayers (outlined below).

Step 1. Set each individual applicator to apply the desired amount per acre as suggested in the equipment operator's manual.

Step 2. Fill hoppers at least half full, turn on applicators and run until all begin feeding.

Step 3. Disconnect nozzle of spreader and attach container under each tube.

Step 4. Travel a measured distance (at least 1/8 mile or 660 feet) at the speed you wish to apply in the field.

Step 5. Weigh the amount recovered for each band separately and record. Use an accurate scale such as a postal or kitchen scale.

Step 6. Calculate the application rate for each unit using Equations 1 and 2 where the band width (in feet) is the swath width.

Equation 1:

$$\text{acres covered} = \frac{\text{Distance traveled (ft) X swath width (ft)}}{\text{43560 (sq. ft/acre)}}$$

Equation 2:

$$\text{application rate (lbs acre)} = \frac{\text{amount used (lbs)}}{\text{acres covered}}$$

-- This is the broadcast rate per acre and the rate the pest is subjected to in the banded area. The amount used per crop acre will be reduced by the ratio of band width to distance between rows.

-- For some pesticides such as soil insecticides the recommended rate is in lbs. per crop acre in which case use row spacing (in feet) for swath width in Equation 1 and your answer will be in lbs. per crop acre directly.

-- If the recommendation is in lbs. per 1000 ft. of row, then:

$$\text{lbs/1000 ft. of row} = \frac{\text{lbs. collected X 1000 ft.}}{\text{distance traveled (ft.)}}$$

Step 7. If the delivery rate isn't within 5% of that recommended on any unit, adjust it accordingly and repeat Steps 3 - 6 until it falls within the 5%.

Step 8. Use the method described for broadcast application during the first part of each application to check the delivery rate. Adjust the settings accordingly.

Soil Fumigation Application

Agricultural (Plant), Ornamental and Turf
(Landscapers, Nurserymen, Turf Managers)

Equipment used for applying liquids or fumigants to the soil varies considerably, but all use one of two basic methods of metering out the liquid fumigant. The method of metering does not affect the efficiency of the material. Preferences of metering equipment are usually based on cost, simplicity, accuracy, practicality and the specific needs of the applicator. The two methods of metering are:

1. Orifice (opening) size is selected to restrict flow from a system which maintains constant pressure at the orifice. Constant speed is necessary to maintain uniform application rates. Pressure regulation varies with the equipment but is usually one of three types.

a. Constant head gravity flow. These units utilize a closed drum or tank with a special breather to establish a constant head of about 1/2 to 1/4 psi, dependent upon height differences between breather inlets to tank and the vented orifice. Needle valves, orifice plates and capillary coils are used to control flow rate. Capillary coils can vary in both length and diameter, but for any one application must be all the same length and diameter for equal pressure and delivery at the outlet.

b. Pump and pressure regulator. Gear, roller, diaphragm or similar pump units utilize either a power take-off or other power source. They generally operate at low to moderate pressures (5 - 20 psi).

c. Gas pressure. This method generally is used with highly volatile fumigants such as methyl bromide. Pressure approved storage tanks and pressurized nitrogen cylinders are used and a constant pressure in the fumigant tank is maintained with one of a variety of pressure regulation devices operating at 5 to 35 psi depending on the fumigant and metering system used.

2. Metering pumps are driven from a ground wheel and are geared to the pump. Full output of the pump or pumps is forced out of the orifices. Changes in output are adjusted by changing the gear ratios and/or the length of the pump stroke. Uniform output is independent of tractor speed. Piston pumps are most common but gear, roller, diaphragm or similar pumps can be used.

Some of the principal methods used for soil treatment are:

1. Injection systems. These are used for fumigants but can be used for other liquid soil pesticides.

   a. Chisel cultivators, blades, or shanks with volatile materials may be 8 inches or more apart; with non-volatile materials, banding or 1 to 2 inch spacing between chisels is necessary.

   b. Sweep-type cultivator shovels.

   c. Planter shoe.

d. Plow.

e. Transplant water.

2. Surface treatment/soil incorporation. This method is used mostly for low or non-volatile materials. Mixing is usually shallow, 5 inches or less. The simplest method is to spray soil, turn it in with disks and compact with a drag, float or cultipacker. Rotary hoes or weeders are also used. Non-volatiles are sometimes applied as granules.

3. Drenching and flooding. These methods are usually used prior to planting, but material may also be applied by irrigation water.

Calibration

This equipment can all be calibrated in the same manner as boom broadcast and band sprayers (See Core Manual). However, fumigant labels usually specify the desired flow rate as fluid ounces per 100 or 1000 feet of travel, or as feet traveled per pint of fumigant. A simpler technique is described below:

1. Establish the speed to be used in application by setting equipment at depth to be used, and then, leaving fumigant valves turned off, drive across a tilled field at a rate that allows a constant travel speed. This speed is determined in feet per minute and converted to feet per second by dividing by 60. If the tractor has a speedometer, its speed per second can be calculated by multiplying miles per hour by 1.45.

2. Determine collecting time:

$$\text{collecting time (seconds)} = \frac{\text{distance suggested on label}}{\text{speed in feet/second}}$$

For example, if the label lists "X" ounces to apply per 1000 ft and speed is 8 ft/second, then:

$$\frac{1000}{8} = 125 \text{ seconds necessary to apply "X" ounces}$$

3. With the orifice pressurized and constant speed units, keep the unit stationary and with pump or pressure system operating at some preliminary setting:

a. Collect the output for the collection time calculated above (Step 2).

b. If the amount is more than 5% above or below the ounces per 100 or 1000 ft recommended on the label, change the pressure or orifices until the right amount is collected.

There are tables available that approximate the output for each fumigant over a range of pressures and orifice sizes.

4. With ground-wheel driven metering pump units:

   a. Determine the circumference in feet of the tire on the ground driven wheel.

   b. Divide the calibration distance by the circumference to obtain the number of turns needed for that distance.

   c. Turn the wheel the calculated number of turns while collecting the output from one or more of the outlets. If the amount is not right, change the gears or sprockets in the drive or change the length of the piston stroke and then recheck the delivery until it is within 5% of the amount recommended on the label.

5. Once field application is started, check the application rate immediately and often thereafter by comparing the amount used and the acreage covered.

   NOTE: Row treatment rates and calibration can be kept less confusing by remembering that flow rates per outlet are usually the same as for broadcast fumigation.

Tarpaulin Fumigation

When odorized methyl bromide (98% methyl bromide, 2% chloropicrin) is used, the area to be treated is generally covered with polyethylene sheeting (tarp). The tarp should be supported off the ground (not flat on the ground) to permit free movement of the gas under the tarp. The tarp should be sealed by laying the edges of the tarp in a small trench or furrow and covering 6 - 10 inches with soil. Care should be taken not to move any of this untreated soil onto the treated area when removing the tarp.

The fumigant can be introduced into evaporation trays using 1 pound for each 100 square feet of area to be treated, and adding the recommended amount of fumigant to each tray. Methyl bromide with 2% chloropicrin added as a warning agent (odorized) is available in small metal pressure cans (1 or 1-1/2 pounds). Also available are applicators with openers each with polyethylene tubing attached to introduce the liquid into the evaporation trays under the tarp. For larger jobs, large cylinders may be used with application tubing attached and utilized in a similar manner to that above. The amount of odorized methyl bromide applied can be measured by placing the cylinder on a scale and measuring loss of weight, or using a special cylinder-metering device attached to the cylinder. In either case, the amount required per evaporating tray is metered out and generally introduced into numerous evaporation trays.

Tarped fumigants can also be injected by tractor-drawn chisel applicators. Commercially, overall tarping is the most efficient and common practice. A tarp layer is mounted behind the chisel applicator. In laying the tarp, one edge of the tarp is buried with bedding disks and the other edge glued to the adjacent laid strip of tarp, with the first strip having both edges buried. Fumigant injection and tarp laying proceeds until the entire field is covered with overlapping strips of polyethylene tarp.

Another less efficient and more time-consuming method is to treat alternate strips of equal width, burying both edges of the tarp. After 1 - 2 days' exposure, the tarps are removed by splitting down the middle, removing each half toward corresponding edge to assure moving the untreated soil, burying the tarp edges into the untreated area for treatment. Injection and tarping are then repeated covering the untreated strips. A third system uses heavier tarps that combine manual, mechanical, and stripping methods of injecting, tarping and covering, allowing multiple spaces between strips. After 1 - 2 days' exposure, the buried far side and ends of the tarp are uncovered, the next strip is injected, the tarp is flipped, and the edges sealed. The process is repeated every 1 - 2 days until each area between the original strips has been treated.

Aerial Application

Agricultural (Plant), Forestry, Ornamental and Turf,
(Nurserymen, Turf Managers)

The key to successful aerial application of pesticides is obtaining uniformity of the initial spray deposit over the plant canopy. The chemical will then be redistributed by dew, rain, or overhead irrigation to other parts of the plant including lower leaf surfaces, stems and fruit. The key to uniform aerial application is the design and adjustment of the spray distribution system and the operation of the aircraft.

The advantages of aerial application are summarized below. The most important is the speed of coverage in order to combat widespread and fast developing epidemics when they strike major large acreage crops such as corn, cereal grain, potatoes, and vegetables. One aircraft can do more work in an hour than most ground rigs can do in a day. Aircraft can spray fields that are too wet for ground equipment, which is often the case when fungus pests are most active. Aerial application must be done by a certified aerial applicator.

Advantages of Aerial Application

1. Faster, better timing.
2. Can be used on wet fields following rain or irrigation.
3. Eliminates wheel damage and soil compaction caused by ground equipment.
4. Reduces mechanical spread of virus and bacterial disease.

5. Uses less water.
6. No runoff.
7. Lowers the grower's capital investment.
8. Reduces labor requirements.

Disadvantages of Aerial Application

1. Some fields inaccessible or too uneven or too small for successful flights.
2. Inherent potential for environmental pollution and drift damage.
3. Certain crops and certain pest problems not suited to aerial application.

Injection and Implantation

Ornamental and Turf (Arborist, Landscapers)

The application of insecticides, fungicides and nutrient elements directly into shade and ornamental trees by injection and implantation are relatively new aspects of practical tree care.

Injection

Solutions are fed by gravity or pressure into holes (drilled or punched) in the trunks or root buttresses just above soil line. Ordinarily, injections are made every few inches around the trunk of a tree in order to insure distribution of the chemical into all the major branches. Pressure is usually provided by compressed air, as from the tank of a hand-operated compressed-air sprayer. Pressures of 10 to 40 psi are effective. Best uptake of solutions occurs on warm sunny days when trees are in leaf. Most movement of injected chemicals is upward; injections are not used for pests and diseases of roots. Suspensions containing insoluble particles are not satisfactory for injection because the particles tend to clog the water-conducting vessels of the wood.

Depth of injection is important. Holes that extend deep into the wood are not desirable. The most effective transport of the pesticide occurs in the outermost sapwood. That is where the injector should deliver the chemical. Injection into deeper lying wood results in failure of much of the

injected chemical to reach the target -- wood of the current season, bark, or leaves.

Diameter of the injection hole is also important. The smaller the better. Small holes heal quickly.

Because healing processes in trees occur in both the wood and the bark after a tree is wounded for injection, an injection site can be used only once. Within several days after a hole is drilled into healthy sapwood, the tree reacts by isolating the wound from healthy tissues. This occurs before visible evidence of healing. Liquids can neither move into or out of a tree through such a wound.

Advantages of Injection

All or nearly all of the pesticide is placed within the tree where it is more or less rapidly distributed upward to the fine branches and leaves. There is little waste, and hazard of environmental contamination is minimal. Heavy, expensive equipment is not required.

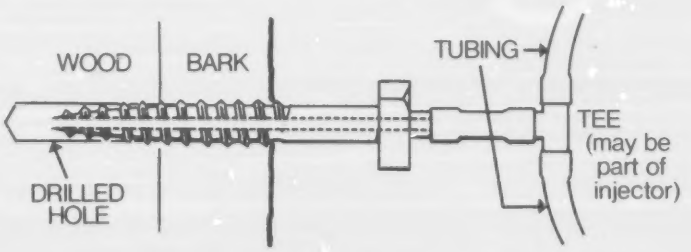
Disadvantages of Injection

Internal distribution of injected chemicals is not uniform. Some branches may receive more chemical than is needed, while others get little or none. For some pesticides applied by injection, the margin between effective dose and phytotoxic dose is small. The proper total dose depends upon tree size and must be determined for each tree to be treated. Bleeding of sap or resin from injection sites sometimes occurs, especially in spring, or if holes have been drilled deep into the wood.

Types of Injectors

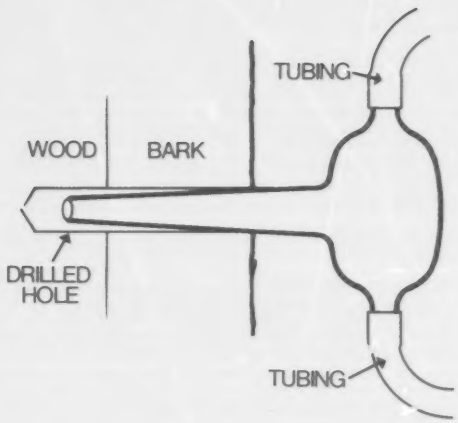
There are as many types of injectors as there are innovating people interested in tree injection. Three general types are shown.

1. Threaded pipe tee or lag bolt with drilled center and split tip, turned into drilled hole. A quick-connect or finger-tight fitting

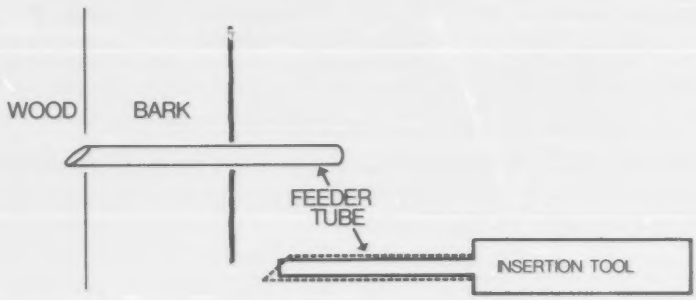


brazed on the bolt head allows connection to feeder line and reservoir.

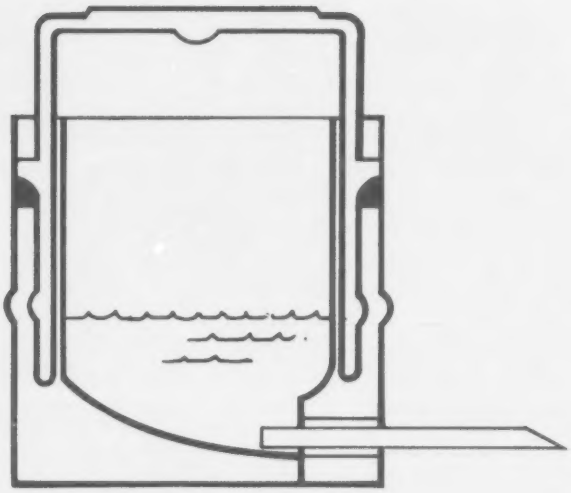
2. Tapered plastic or wood spile, tapped into drilled hole, held in place by friction, connected by finger-tight fittings or plastic connectors to feeder lines.



3. Aluminum feeder tube, driven into trunk using a special insertion tool. Insertion tool has a solid steel shaft on which the feeder tube fits as a sleeve while being driven through the bark. Blunt end of shaft penetrates easily only to the wood, thus positioning the tip of the tube in the outermost sapwood. Feeder tube is then connected to

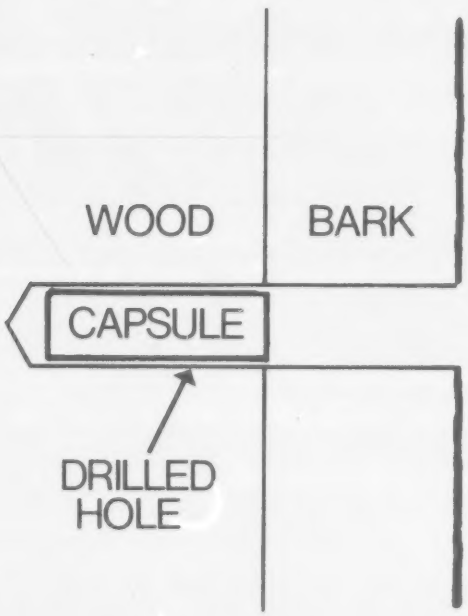


delivery tubing or, usually, to capsules that act as separate reservoirs. Contents may be pressurized slightly, after connection to feeder tube, by squeezing together the two halves of the capsule.



Implantation

Solid chemicals, usually in water-soluble capsules (or plastic capsules with soluble membranes over perforations) are inserted into holes drilled into the outer sapwood. Sap from the living wood dissolves the capsule or membrane and the chemical. This allows the chemical to be carried upward in the sap stream.



Capsules are inserted so that the outer end is flush with the surface of the wood, and are not removed.

In comparison to injection, implantation has the advantage that a tree need be visited only once for application of the pesticide, and no specialized equipment is necessary. The main disadvantage is that the technique can be used only for applying small amounts of chemicals.

OPERATING PRECAUTIONS FOR PESTICIDE EQUIPMENT

1. Never use a pin, knife, or other metal object to unplug a nozzle. Use compressed air, an old toothbrush, or a brush with soft bristles. Never blow into a nozzle to clean it.
2. Never allow dirty water or debris to enter the tank.
3. Control spray drift by:
   a. Using the largest nozzles and the lowest pressure that will apply the pesticide properly.
   b. Keeping the boom as low as permissible.
   c. Spraying on days without wind or breeze.
4. Do not use corrosive fertilizer solutions in an ordinary weed sprayer. Parts made of brass, copper, steel, aluminum, or even galvanized materials may be severely damaged, unless the sprayer is cleaned carefully.
5. Never operate a sprayer with any of the screens or filters removed. If the screen constantly becomes plugged, replace it with a screen of the proper mesh and capacity.
6. Never fasten a power take-off driven pump solidly to the tractor. The chain provided will keep most sprayer pumps from rotating. Fastening the pump with a bar usually causes rapid bearing wear.
7. Never allow any sprayer pump to run without water, even for a short time; pump seals, bearings, and other working parts may be severely damaged.
8. Always pump a large amount of clean water through the sprayer at the end of the day or when changing from one pesticide to another. Clean all nozzle tips and screens at the same time. This helps reduce the gummy deposits or the accumulations of wettable powders in the sprayer.
9. Airblast or mist sprayers are designed to apply insecticides and/or fungicides. They should never be used to apply herbicides, especially hormone-type herbicides such as 2,4-D.

CLEANING THE SPRAYER

There is no satisfactory way to completely remove all traces of any herbicide from a sprayer. Traces of chemicals in solution (2,4-D, for example) cannot be completely removed from porous tanks, or from hoses, pressure regulators, selector valves, or screens. If a herbicide sprayer must be used to apply an insecticide or fungicide, do not apply the insecticide or fungicide to a crop that may be damaged by the herbicide. Chemicals in suspension (such as atrazine) may not be as difficult to remove from the sprayer, but traces may still be present unless all parts are thoroughly cleaned.

END OF THE DAY CLEANING

At the end of the day or whenever wind or weather conditions force you to stop spraying, clean the sprayer to prevent gum or powder deposits in the pressure regulator, selector valve, nozzle tips, and screens.

Follow these steps:

1. Rinse the inside and outside of the tank three times with clean water.
2. Put in a moderate amount of clean water and spray it out. A small amount of liquid detergent added to the water will help clean the inside of the sprayer system.
3. Clean the nozzles, nozzle screens, and suction screens with compressed air or a soft brush. Replace the screens and nozzles.

   CAUTION -- Never clean a sprayer near susceptible plants or where the wash water could contaminate farm ponds, streams, or other supplies of water.

STORING THE SPRAYER

When you store your sprayer properly, you add years to its useful life.

1. Clean the sprayer thoroughly.
2. Completely lubricate all moving parts according to the manufacturer's recommendations.
3. Make a list of all faulty parts and order the new ones to be ready for the following spring.

4. Fill the tank with water and add the recommended quantity and type of rust inhibitor or new light oil (see your instruction manual). Drain the tank. Leave all tank openings uncovered for ventilation, but screen them to keep out dust debris, insects and animals.

5. Clean all nozzle tips and screens with compressed air or a soft brush and kerosene. Store the tips and screens in a jar of new light oil or kerosene.

6. Take the weight off of any tires.

7. Remove, clean and drain the pump. Fill it with the light oil, anti-freeze or rust inhibitor recommended by the pump manufacturer. Seal all pump openings to keep out dust, dirt, insects and animals.

   NOTE -- Make certain that no water is left in the pressure regulator, selector valve, or the boom. These parts will be severely damaged if water freezes in them.

SOME COMMON SPRAYER TROUBLES

Problem	Cause	Remedy
Loss of Pressure	1. Pressure regulator improperly adjusted or stuck open.	1. Adjust pressure regulator.
	2. Suction screen plugged.	2. Clean screen thoroughly.
	3. Suction hose cracked or porous.	3. Replace hose.
	4. Pump worn.	4. Replace or recondition pump according to manufacturer's instructions.
	5. Nozzle tips or orifices worn.	5. Replace nozzle tips or orifices.
	6. Gauge faulty.	6. Replace gauge.
Excessive Pressure	1. Pressure regulator improperly adjusted or stuck closed.	1. Adjust pressure regulator.
	2. By-pass hose plugged or too small.	2. Unplug the hose or replace it with a larger one.
	3. Gauge faulty.	3. Replace gauge.
Pressure gauge needle jumps excessively	1. Gauge too sensitive.	1. Replace gauge or mount a flow restrictor or needle valve.
	2. Air cushion for the surges in liquid flow is gone (surge tank is waterlogged).	2. Admit air into the pump's air chamber, or install an air chamber on the pressure side of the pump.
Plugged nozzles	1. Nozzle screen too coarse.	1. Replace with the proper mesh screen.
	2. Water, chemical, or tank not clean.	2. Drain tank and clean thoroughly; check suction screen for holes.
	3. Nozzles too small.	3. Replace with the proper nozzles for the chemical being used.
	4. Boom plugged.	4. Remove the plugs in the ends of the boom section to clean the boom.

IV. VEGETABLE AND POTATO PESTS

Special Problems

The commercial applicator who works with vegetables and potatoes must be aware of many different problems because he works with many different crops and pests. You will probably be working with a variety of pesticides, several of which are highly toxic. You must always be careful of exposing yourself and your help, both when mixing and applying pesticides. Adequate clean protective clothing and equipment is necessary. You may use high pressure equipment which makes many fine droplets that will drift both on you and away from the target or low pressure, low volume equipment that produces fewer fine droplets but those produced are of a higher concentration. Airblast equipment combines many fine particles with high concentration. You may even be using dusts under some circumstances. As you turn at the end of the row you frequently move back through a drift of fine droplets or particles of the pesticide that you are using. Protect yourself accordingly.

Many vegetable fields border sensitive areas--backyards with vegetable gardens, ornamentals, children and toys; pastures, other crops, barnyards, streams, beeyards, roads, etc. Be sure not to drift hazardous pesticides onto them. You may want to use equipment that is less likely to drift in a sensitive situation, or adjust your equipment to drift less through lower pressures, larger droplets, etc. If airblast equipment is used the output should be directed away from the sensitive area for several swaths even though this may not be the most favorable direction for treating the rest of the field.

You must also be careful not to drift the registered pesticide that you are using on one vegetable crop to a different vegetable crop in the neighboring field or even in the same field. The pesticide may not be registered for the second vegetable or there may be residue or phytotoxicity problems. Similarly, the herbicide that you safely and legally use on one vegetable may be deadly to a nearby vegetable. Check also to be

sure that the crop following the one on which you use a herbicide can be planted with no risk of damage from soil contaminated by the herbicide. If you are applying a vine killer to potatoes, remember that injury from any drift will be highly visible on surrounding crops, ornamentals, and pastures.

While it is the grower's responsibility to notify his workers, you should be sure he is aware of the use of any pesticide having the special reentry period of 24 or 48 hours. Otherwise he may allow the workers to reenter the treated field too soon and be faced with an exposure problem and subsequent investigation. Be sure also that your client is familiar with the days to harvest limitations.

Since many vegetables are grown on the muck and since drainage ditches make convenient spots from which to fill, the possibility of water contamination is high. Take particular care that your filling procedure does not allow backsiphoning into the water source; that you do not allow the sprayer to run over and drain back into the water or leave puddles which may be toxic to bees, animals or people; and that you dispose of your used pesticide containers in a safe manner.

Application Methods and Equipment

Application equipment commonly used for treating vegetable crops includes sprayers for handling liquids, granular equipment for applying dry pesticides, fumigation equipment, and agricultural aircraft which can apply either wet or dry materials. The following outline refers you to the appropriate pages in Chapter III.

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Some Vegetable Insects

Aphids

Description

Aphids are soft-bodied, small and usually green in color. They are generally noticed when in colonies on the underside of leaves or on the stem of host plants. Affected plants react in different ways to aphid damage. Cabbage leaves turn yellow and cup strongly inward; other plants turn yellow, wilt or are stunted in appearance. Aphids have two forms, winged and wingless. Either or both forms may be found on the same plant at the same time depending on plant vigor and time of year.

Green peach aphids of this group are about 1/16" long and sluggish. They have two conspicuous antennae attached to their heads and two projections on the rear of the body called cornicles.

Life Cycle

In the spring the aphid eggs hatch (the fertilized eggs were deposited in the previous fall). The new aphids feed on their overwintering host (usually a wild tree of the peach/plum group) and grow to adults. All which hatch from the overwintered eggs are females which give birth to living young. The next generation is winged and flies to a wide variety of host crops, such as lettuce, celery, peppers, potatoes, tomatoes to name a few. During the summer there is no egg stage, and there are no males. The mother aphids produce living young, all females, and they mature in seven to 10 days. Because of the type of reproduction and the short life cycle, there are several generations per year and fantastic numbers can build up very quickly.

When the day length shortens, a fall-winged generation is produced which includes both males and females. These fly to their winter host trees, mate and fertile eggs are deposited as the overwintering form for a new generation in the next year.

Damage

Aphids have sucking mouthparts. Large numbers of aphids weaken plants by sucking the vitality from the plant. Affected plants turn yellow and are often stunted in their growth. More important than the sucking injury is the ability of this aphid to carry and transmit plant disease organisms. The green peach aphid alone carries over 100 different plant viruses. Some of the more important affect potatoes, lettuce, peppers and corn.

Cabbage Looper

Description

Cabbage loopers cause significant damage to crucifer and several other cabbage family crops yearly on the East Coast. The looper larva is a pale green caterpillar marked with two dorsal (top) stripes and a white stripe on each side of the body. It crawls with a peculiar looping motion like a measuring (inch) worm. It has only three pairs of abdominal prolegs, compared to five pairs for the imported cabbage worm and diamond-back moth. When full grown looper larvae are about 1-1/2 inches long, the mature larva forms a loose silken cocoon in which it pupates on the leaf of the host plant. The adult is a greyish-brown moth with a silvery spot on each front wing. It is nocturnal in habit and rarely seen.

Life Cycle

This insect does not normally overwinter in any stage in New York. The infestation which occurs in most seasons is due to adults which fly in from southern areas. The nocturnal (night flying) moths lay small greenish-white spherical eggs singly on the leaf undersurface of host plants. The eggs hatch in four or five days and the loopers mature in two to three weeks. When present there are usually three generations in a season in upstate New York.

A virus disease attacks the looper in nature. In some seasons the disease outbreak may afford significant control. However, it usually activates too late in the season in most years to be effective.

Damage

The looper feeds on the leaves of its host plants and bores into the heads much as does the imported cabbage worm. Because it is somewhat larger and feeds for a longer period, the injury it inflicts is often more serious. It is a contaminant in the heads of broccoli and cauliflower, often causing processors to reject the crop. This insect attacks all plants of the cabbage, or mustard, family as well as many other plants such as lettuce, spinach, pea, celery, parsley, potato and tomato.

Colorado Potato Beetle

Description

The Colorado potato beetle is a native American insect first described in 1824 from the upper Missouri River Valley where it used to feed on a weed called buffalo bur or sand bur. When early settlers first began to plant potatoes, the beetles discovered the new food plant and liked it.

Adult potato beetles are yellow and have 10 black longitudinal stripes on their wing covers. They are about 3/8 inch in length. The larvae (or slugs as they are sometimes called) are brick red in color, hump-backed, soft-bodied and are a bit more than 1/2 inch in length when full grown. They have two rows of black spots on either side of the body. The orange-yellow eggs are deposited on the underside of the leaves, in close-standing groups averaging 25 eggs each. Over a period of four to five weeks each female beetle will lay several batches of eggs until about 500 are deposited.

Life Cycle

The adult beetles come out of winter hibernation in mid-May on Long Island and a week or 10 days later in central New York just before the early planted potatoes are up. Clusters of 20 or more eggs are laid on the undersides of the leaves soon after the beetles emerge. The eggs hatch in seven to nine days. The larvae (or slugs) feed on the foliage, grow rapidly, and complete their development in 18 to 21 days. The full grown larva burrows into the ground and changes to the pupa or resting stage. After seven to 10 days the adult beetle emerges from the pupa, crawls up out of the ground and after a short period of feeding, lays eggs for a second generation. The two major damage periods occur in May/June and August.

Damage

Larvae and adults feed on the foliage of potato, eggplant, tomatoes, and peppers. They may reach large numbers and eat all the foliage from the plant as well as spoil the fruit by eating into it. They are especially destructive to small plantings and are often very abundant in large plantings of potatoes such as on Long Island.

Corn Earworm

Description

The corn earworm is identified with the crop in which it feeds and thus since most of its damage is done on corn in New York it is known

as the corn earworm. The same insect when feeding on cotton is known as the cotton bollworm and when on tomatoes as the tomato fruitworm.

The adult is a yellowish-brown moth with a wingspan of 1-1/2 inches. The moth belongs to the same family as the armyworm moth, which it resembles. The larva has a tan colored head and is 1-1/2 inches long when fully grown. The body has prominent longitudinal stripes and may vary in general color from yellowish green to black with shades of pink or brown. It should not be confused with the European corn borer which seldom exceeds one inch in length, is dirty-white in color, with a dark brown or black head. The whitish eggs, about half the size of a pinhead, are ribbed and shaped like a flattened ball.

Life Cycle

The earworm does not normally pass the winter successfully in New York. However, under very favorable conditions a few pupae may survive on Long Island and in the lower Hudson Valley. It is believed therefore that most of the earworm infestations in the state originate from moths that migrate from the South. There are two generations and possibly a third each season on Long Island and in adjacent parts of the Hudson Valley. In these areas earworm injury occurs in July and from late August to the end of the season. In upper New York a single generation, usually in limited numbers, affects principally late-maturing sweet corn in late August or early September.

Eggs are laid by the moth on fresh corn silks and hatch in two or three days, depending on temperature. The newly hatched worms pass through the "silk channel" feeding along the way, to the kernels of the developing ear where feeding continues until development is complete.

Seldom does more than one worm reach maturity in any given ear because of a well developed cannibalistic tendency. Mature worms travel to the ground where they pupate.

Damage

The corn earworm is a general feeder, but most often attacks sweet corn or field corn in this state. Tomatoes also may be a host in years of heavy infestation. In corn the earworm feeds for the most part on the developing kernels at the tip of the ear. The mere presence of the earworms and their abundant, unsightly excrement at the tip of the husked ear is enough to lower crop value. The Euorpean corn borer, unlike the earworm, commonly attacks all parts of the ear and frequently tunnels into the ear.

European Corn Borer

Description

Few insects have attracted more attention than the European corn borer. As its name implies, it is a native of Europe where it has long been a serious enemy of corn, especially in Central Europe.

In New York State corn is the main host plant of this insect, but many other plants may be attacked. The adult female is a yellowish-brown moth with irregular dark lines in geometric patterns across the wings. The male is slightly smaller and more heavily marked with darker brown. The moths have a wingspan of about one inch.

The larva or borer is dirty-white and about one inch long when fully grown.

Life Cycle

The borer larvae overwinter in their burrows in corn stalks or weed stems. All of New York State, except the extreme northern and Adirondack counties, has the two brooded strain of this insect. Larvae pupate in their overwintering quarters in May and by May 20 - 30 the moths start to emerge. These moths lay flattened eggs in overlapping scale-like masses containing 15 to 20 eggs on the undersides of the leaves. Most larval invasion of the plants takes place in the whorl state.

First brood worm activity is at its peak in June. The second brood worms are particularly troublesome in the ears during August in most of the state. The second brood borers start their damage later in August upstate so will continue their feeding into September.

Damage

Corn is the main crop damaged but the borer has a wide range of host plants which include both cultivated plants and weeds. On some of these plants the insect is capable of passing through all its stages while others afford only temporary shelter and food. Some of the more important cultivated plants which have been found infested in addition to corn are lima beans, snap beans, beets, eggplant, Swiss chard, peppers and potatoes. Potatoes form an important link in the life history of the insect on Long Island since a large number of the borers of the first brood mature in the vines of this crop. Some of the weeds which are commonly infested are dock, smartweed, ragweed, barnyard grass, and pigweed.

The major damage caused by this insect to fresh market and processing sweet corn is to the ears. Borers tunnel up the ear shank and often into the cob where they cover the surface of the kernels in several locations. In years of heavy infestations, borers may be so numerous that severe stalk damage occurs causing the stalks to bend or break over making anything but hand harvest impossible.

Mexican Bean Beetle

Description

The Mexican bean beetle is about 1/4 inch in length, and convex in form. Each wing cover has eight black dots in three rows across the body. Overwintered adults are copper colored, whereas newly emerged adults are yellow. The larva is yellow, with long black-tipped spines. The eggs are orange in color and laid in a cluster on the underside of the leaves. This insect is a member of the ladybird beetle family. Most other ladybird beetles are considered to be beneficial to man for they prey upon other insects.

Life Cycle

The adult beetles pass the winter under trash of the ground cover, along hedgerows and in similar protected locations. They appear on beans in June and soon begin to lay clusters of 20 to 50 eggs on the lower surface of the leaves. In 10 to 14 days the eggs hatch to produce spiny lemon-yellow grubs which feed mostly on the undersides of the leaves. When full grown, the larva or grub is 1/3 inch in length. Pupation takes place on the bean leaves. The pupa is orange in color and is attached to the leaf in means of the old larval skin. All life stages of this insect can be found on the leaves of the bean plant at the same time. Adult beetles usually live four to six weeks during the active summer season.

There are two generations a season. The total period of development from egg to adult averages 33 days in mid-summer.

Damage

Because there are two generations per season there are two peak periods of injury during the growing season. The first is caused by

feeding of the larvae during the month of July and the next is in late August from second generation larvae. The adults and larvae feed almost exclusively on the undersides of the foliage. The leaves are often skeletonized to a lace-like appearance not easily confused with other insect injury. Yields from damaged plants are reduced. This insect feeds on snap, kidney, pinto, navy, lima and other beans including soybeans.

Onion Thrips

Description

Onions are often injured by a small yellowish or brownish insect called the onion thrips. The adult female thrips are about one twerty-fifth inch in length. It is slender, with four narrow wings fringed with hair. The pest is so small it is difficult to see with the naked eye--so small that growers do not see it. The young, or nymph, is pale yellow and similar in form to the adult.

Life Cycle

The onion thrips pass the winter in both the adult and nymphal stages on onion plants left in the field and in onion rubbish piles and along the edge of the fields. The female inserts her minute whitish eggs into the tissue of the leaf. The eggs hatch in from a week to ten days. The nymph passes through two stages while feeding on the plants and then enters the ground, where it passes through two more immature stages before becoming adult. The life cycle is completed in about twenty-six days. There are five or six generations annually and breeding is continuous until stopped by cold weather.

Damage

Both the adult and nymph feed by rasping the surface of the leaf with their mouthparts and feeding on the sap that flows from the damaged tissue. The injured areas appear as small white or silvery blotches on the foliage. Heavily infested plants become stunted, whitish, wilt and fall over. Adults and nymphs are found in greatest numbers hidden under the sheath at the base of the leaves and between the young leaves at the center of the plant. This pest is often a serious threat to muck grown onion crops in New York. Injury is most severe, however, during hot, dry seasons.

Onions grown from seed are more severely injured by the thrips than are those grown from sets, but the latter, when heavily infested, serve as a reservoir from which the insects spread to seed onions.

In addition to onions, thrips feed on beans, cabbage, cucurbits, corn and a large number of other field and garden crops, and weeds.

Potato Leafhopper

Description

The adult potato leafhopper is a pale, pea-green, wedge-shaped, sucking insect about 1/8 inch long. The nymph or immature leafhopper is yellow to a yellowish-green color. Both the adults and nymphs run sideways or backward very rapidly and usually try to keep on the underside of a leaf as it is turned over.

The insect does not overwinter in the northern United States, but only in the extreme southern fringe of the deep south or possibly Mexico. Each year the New York infestations are the result of migratory flights from areas to the south. The insect moves northward from its overwintering

quarters with the warm spring winds and weather systems. It usually arrives in Central New York in early June.

Life Cycle

When adult potato leafhoppers arrive in New York each June they concentrate on bean crops, potatoes and alfalfa where they feed and lay eggs. The eggs are laid in the large veins and petioles of the plant leaves. The eggs hatch in about 10 days, and the young nymphs are similar in shape to the adult but smaller and lighter in color. Under favorable conditions, the insect develops from egg to adult in about three weeks. In New York several overlapping generations are produced which overlap in the field and cannot be definitely distinguished. Adults and nymphs continue to feed on host crops until they are killed by severe fall frosts.

Damage

Nymphs and adults of the potato leafhopper have sucking mouthparts. This insect feeds on and damages many crops including beans, potatoes, and alfalfa. When heavy populations of leafhoppers are present damage symptoms are expressed on foliage of beans as leaves cup downward in umbrella-shaped fashion.

When it is feeding on potato the first indication of its damage is a yellowish to brown triangle at the tip of the potato leaf. Similar triangular brown areas may appear at the end of each lateral leaf vein so that the entire edge of the leaf turns brown and rolls upward. Old leaves near the base of the plant, usually brown first but in heavy infestations the entire plant may turn brown as if scorched by fire. Injury on potato is referred to as "hopperburn".

Seed Corn Maggot

Description

The adult fly resembles the common house fly but is greyer in color and has long legs. The larva or maggot is the destructive stage and is

white and legless. Its body is tapered toward the head and had a pair of strong black hooks for feeding. When full grown the maggot is 1/3 inch in length. The pupal stage looks much like a grain of wheat, is tan or reddish in color and is located in the soil near the base of the damaged seedling.

Life Cycle

The maggot overwinters in a puparium in the soil. Adult flies emerge in the spring and seek damp soil in which to lay tiny cylindrical white eggs. Moist soil containing decaying vegetable matter is preferred for egg laying. Soil containing decaying roots of weeds, clover or alfalfa is especially attractive to the flies for egg laying.

The eggs hatch in two to four days and from them small white maggots emerge. These make their way to the decaying vegetable matter upon which they feed and develop, or to sprouting seeds, or recently set plants. In some seasons such as those with cool wet conditions, egg laying may extend over a considerable time for the first-brood adults. The maggot becomes full grown in about three weeks. The second brood of flies appears in late June to early July and a third brood may appear in late August to early September.

Damage

In years of excessive rainfall during May and early June, growers of field dry beans, snap beans and lima beans are likely to experience heavy losses from destruction of the germinating seed by the seed corn maggot. When the maggots burrow into the seed they destroy or badly damage the growing point between the two halves of the seed. If the growing point is destroyed, the plant comes up in a deformed condition and the injured plant is known as a "snakehead" or "baldhead". Injured plants are stunted and die. Injured plants which survive produce poorly.

Sometimes an entire field is so badly injured that the crop has to be abandoned and the land refitted for some other crop. This degree of injury may result also when beans are planted so that they sprout when a generation of maggots is active. In addition to beans, the seed corn maggot also attacks peas, corn, radishes, cucurbits and crucifer crops.

Striped Cucumber Beetle

Description

The striped cucumber beetle is the most important insect enemy of cucumber, melon, squash, and related crops with which the growers of New York have to contend. The adult is 1/5 inch long with a black head, yellow body and wing covers that form three distinct longitudinal black stripes when folded. The larvae are white with brown heads and are about 3/8 inch long when full grown. They feed on the underground plant parts and burrow into the vines where they rest on the ground. Sometimes the main stem just below the soil surface becomes riddled with the burrows of the larvae, and the plant becomes seriously weakened or even killed.

Life Cycle

The cucumber beetle hibernates under trash and in patches of woodland, often some distance from the fields in which they breed. The beetles emerge from hibernation early in the spring and feed for some time on the leaves and the flowers of various wild plants. The adult beetles enter the growers' fields and congregate on cucurbit plants just as the plants are coming up. They feed on the leaves and gnaw holes in the stems near the surface of the ground. The beetles deposit most of their eggs in crevices in the ground near the base of the plants. The eggs hatch in about a week and the small white larva burrow into the underground portion of the young plants, where they complete their development in a month. Pupation takes place in the soil and lasts a week or more. During late August the

new brood of adults emerges, they feed on flowers, fruits and foliage of cucurbits until the first heavy frost, then go into hibernation.

Damage

This insect is the major pest of cucurbits in New York. The first and greatest damage results from adults feeding on stems and seed leaves when the plants are pushing through the ground before true leaves have developed.

Later in the season when another generation of beetles appears, the leaves, blossoms, and fruits of vine crops may be seriously damaged. Even greater losses are caused by the insect as a vector of bacterial wilt. The bacillus causing this diseases overwinters in the body of the beetles.

Summary - Some Vegetable and Potato Insects

Name of Pest	Type of Feeding	Plant Type Attacked	Plant Parts Attacked	Signs of Injury	Recognition of Insect	Pest Life Stage to Control	Control
Aphids	Sucking	Cabbage Broccoli Celery Corn Lettuce Potato	Stem Leaf Flower	Sticky leaves with black socty fungus, leaves cupped, wilted, stunted or yellow	Soft, small, green insects--1/16" long	Nymph and adult	Chemical: Treat when aphids appear. Cultural: Disc harvested crop refuse.
Cabbage Looper	Chewing	Cabbage Broccoli Celery Lettuce Many others	Leaf	Holes chewed in leaves	Green worm up to 1" long, moves by looping action	Eggs and small larvae	Chemical: Apply chemicals when young larvae present. Cultural: Disc crop refuse.
Colorado Potato Beetle	Chewing	Potato Tomato Eggplant Peppers	Leaf Fruit	Holes chewed in leaves, may chew into fruit	Larva--1/2" long, reddish, hump-backed, adult-- yellowish-tan with black stripes	Larva and adult	Chemical: Treat when first larvae present. Cultural: Destroy volunteers in field and tubers in dump locations.
Corn Earworm	Chewing	Corn Tomatoes	Ear Fruit	Holes in tomatoes, worm in tip of corn ear	Green, tan or pink larva--worm up to 1 1/2" long	Eggs Young larva	Chemical: Treat silks in August and September. Cultural: Choose varieties with tight long ear husks.
European Corn Borer	Chewing	Corn Many other vegetables	Stalk Leaf Ear	Feeding on leaves, tunnels in stalk	Larva 1" long, dirty-white wormlike	Larva	Chemical: Apply control when leaves show pinholing. Cultural: Plow fields in fall.
Mexican Bean Beetle	Chewing	Beans Soybeans	Leaves	Skeletonizing of leaves	Yellow larvae with black spines, adults bronze color with 16 black dots on back	Adult and Larva	Chemical: Spray when larvae start to damage leaves. Cultural: Disc crop after harvest.

Summary (Cont'd.)

Name of Pest	Type of Feeding	Plant Type Attacked	Plant Parts Attacked	Signs of Injury	Recognition of Insect	Best Life Stage to Control	Control
Onion Thrips	Chewing Rasping	Cabbage Lettuce Onions Celery	Heart of plant, Onion Leaves	Silvery color in damaged areas, plants stunted, wilted, falling over	Adult-nymph, brown, tiny, 1/25" long, adult with 4 feathery wings	Nymph and adult	Chemical: Spray when injury first shows. Cultural: Disc crop after harvest.
Potato Leafhoppers	Sucking	Alfalfa Beans Potato Many others	Leaf Stems	Beans--leaf edges dry and turn under Potatoes--heavy infestations cause "hopperburn"	Nymph-wedge-shaped, green, small	Nymph and adult	Chemical: Treat when nymphs and adults numerous but before damage shows. Cultural: Disc crop after harvest.
Seed Corn Maggot	Chewing	Corn Cabbage Broccoli Cauliflower Brussels sprouts Radish Turnip Onion	Seed Lower stem below ground so that growing tip is destroyed	Maggots on or in root and lower stems, new plants forming "snakeheads"	Maggot-white legless-1/3" long, adult resembles housefly	Fly and maggot	Chemical: Treat seed with insecticides. Cultural: Follow timely shallow planting schedule.
Striped Cucumber Beetle	Chewing	Cucumbers Melons Squash	Newly set plants Leaf	Severe chewing of new leaves while still small	Adult-yellow with black stripes	Adult	Chemical: Protect newly emerging plants through the runner stage. Cultural: Clean up crop refuse.

Some Vegetable Diseases

Bacterial Blight (Beans)

Symptoms

Two blights occur on beans, common and halo. The former appears first as small water soaked areas on the leaves. As these enlarge their centers become dry, brown and with a narrow yellow halo. Pods develop water soaked blotches with a yellow gummy exudate. Halo blight causes a small leaf spot with a very wide pale green halo. Halo blight can be systemic and cause the entire plant to turn brown.

Pod infections are "greasy" and have white exudate.

Disease Cycle

Infected seed is most likely the source of infection and can remain infective as long as the seed is viable. Crop debris, especially stubble left standing can provide inoculum from one crop year to another. After the seedling becomes infected from seed or debris the bacteria gain entrance to the new seed to complete the life cycle. Splash, blowing rain, and mechanical transmission are main methods of dissemination.

Damage

Early or seed-borne infected plants may die early or produce few useable pods, therefore, loss of stand, yield and quality results from bacterial blights.

Downy Mildew (Cabbage)

This fungus disease affects nearly every species of cultivated and weed plant of the mustard and cabbage family. Each crop has a distinct strain of the fungus so the one on cabbage and cauliflower will not attack radish and vice versa.

Symptoms

The mildew is first noticed as a slight yellowing on the upper side of the leaf. In moist weather, a white growth appears on the under side of the spot. The spot enlarges until the leaf dies, especially on radish. On older lower cabbage leaves, the spots are irregular and cause the leaf to turn yellow but not die.

Disease Cycle

Spores of the fungus enter the leaves, cause infection, and reproduce rapidly to form new spores. The fungus overwinters in the soil as fungus threads and oospores. We don't know how long the organism can live in soil without a host crop. Spores won't germinate unless the air is saturated with water and the temperature is 65 or below. Higher daytime temperatures, however, favor the entrance of the germ tube into the leaf.

Damage

Loss of leaf tissue on small transplants is the main loss; however, if the disease progresses up the maturing cabbage or cauliflower plant soft rot bacteria will enter the spots and cause a soft smelly rot of the head.

Early Blight (Tomatoes)

This fungus is very common in home gardens and on commercial farms where short rotations are used. A fungicide program is necessary to really control this disease in average summers.

Symptoms

Early blight is characterized by brown, irregular spots with concentric rings in a target pattern on the lower leaves. On old fruits, a black leathery sunken spot may form near the stem end. Although the

disease always appears first on the lowest leaves, it works on up the plant causing spots and yellowing of the leaves. Irregular brown spots may occur on the main stem and leaf petioles also. When leaves turn yellow and drop off, the fruits are exposed to the sun and either scald or have poor color.

Disease Cycle

The fungus overwinters in old diseased plant tissues and will remain alive at least until the tomato stems and leaves are completely rotted. Related weed hosts such as jimson weed, horsenettle, ground cherry, and nightshade may keep the fungus alive in any field. Wet and warm weather (80°F) favor growth and dissemination.

Damage

Defoliation is main damage, although some fruit rot can occur.

Onion Leaf Blight

Two fungi can cause leaf blight in onions in New York. Botrytis is the most common and serious leaf blighter on muckland onions whereas Alternaria attacks sweet Spanish large onions with a purple blotch symptom. Control of each is best achieved with regular fungicidal applications.

Symptoms

Leaf blight (blast) caused by Botrytis squamosa appears as discreet

paper gray spots on the leaves soon followed by browning and death of the upper portions of the leaves. Immature undersized bulbs result. It is favored by warm highly humid weather.

Alternaria purple blotch causes large brown-purple spots on the onion foliage and dime size black spots on the onion bulb at harvest.

Onion Leaf Blight (Botrytis)

Disease Cycle

Both fungi overwinter in old crop debris and produce spores early in the next season. The Botrytis fungus has a hard black resting structure called a sclerotium in which it overwinters from which new spores are produced. The Alternaria fungus lives over in the debris.

Damage

Main damage is loss of foliage reflected in smaller bulbs. Alternaria may also spot the bulbs.

Powdery Mildew of Cucurbits

This fungus may affect muskmelons, squash, pumpkins and cucumbers.

Symptoms

The fungus appears as a white talcum-like growth on the upper sides

of the leaves and petioles although later it may also move to the lower side of the leaves.

Disease Cycle

Spores of the fungus produced on the surface of the leaves blow to healthy leaves and directly invade them. Fungus growth is favored by high temperatures and the absence of dashing rains. In cool wet summers the mildew may not appear. Overwintering is probably in or on perennial weeds but most spores are thought to be blown up from the south as cucurbit crops move progressively northward. The fungus is influenced greatly by age of the plant, air humidity and temperature. Very young leaves are nearly immune. Seed treatments and rotation have no influence on control.

Damage

Early loss of leaves before fruits have reached good size stops growth of the plant. Fruits exposed to sun by loss of leaves may be poor in color.

Sclerotinia White Mold of Beans

This is the most serious disease of green beans as it not only severely

damages the growing plant but it attacks the pods causing a soft rot at harvest and also in transit and short term storage.

Symptoms

Irregularly shaped water soaked spots on the stems followed soon by similar spots on the branches, pods and leaves. Single plants located adjacent to sclerotia may turn brown and die early. Pods develop wet greasy spots often with a white cottony growth in evidence. These pods in a basket will turn into a watery mass with brown drops of liquid appearing in the white mass. Soon small black bodies (sclerotia) appear among this cotton.

Disease Cycle

The hard black sclerotia act as the overwintering stage of the fungus. They resist freezing, and drought. In spring these structures open up and send out a structure on which ascospores are produced in abundance. If these spores land on a susceptible host a new infection occurs.

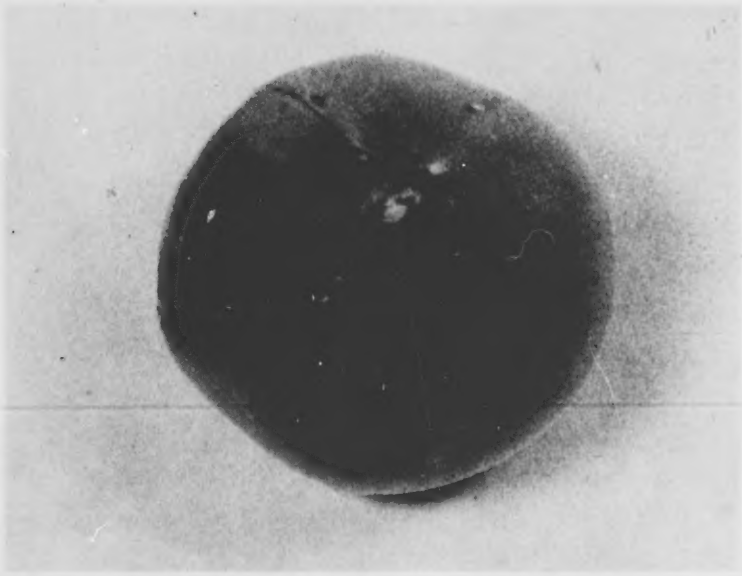
Blossoms are especially favorable sites for the fungus to increase and produce new spores. After some time passes and damage has been done the fungus begins producing these black sclerotia for next year. These serve as the main method of dissemination from field to field and area to area. High humidity, high fertility of the crop, close spacing of plants and short rotations all favor the disease.

Damage

Death of individual plants, loss of many leaves on others, and especially pod rotting are the main types of damage. Processors often reject entire bean fields when only a few infected pods are detected in a load of beans. Thus losses are greatly magnified. In dry beans individual plants die and beans shrivel and lose their red color.

Tomato Anthracnose

This is the most serious fungus disease of processing tomatoes and those ripe fruit from home gardens.



Symptoms

Anthracnose is a tomato fruit disease rather than a foliage or stem disease. In small green fruit the spots appear as tiny circular sunken areas and may go unnoticed until the fruits begin to ripen when the spots suddenly get bigger (about the size of a dime) and become very sunken. In their centers black fungus spores develop. Other soft rotting fungi and bacteria gain entrance and often a watery soft rot results.

Disease Cycle

The fungus lives overwinter not only in old diseased vines and fruits but also on and in seed. The fungus becomes active early in spring and causes almost invisible spots on leaves where it produces many spores that infect the green fruit with scarce symptoms at that time. The pathogen will grow at temperatures between 55 and 95°F but its optimum is 80°F. Thus when temperatures are high with abundant rainfall in August, anthracnose may become epidemic.

Damage

Loss of ripe fruit through rotting.

Some Potato Diseases

Early Blight of Potato

Early blight is caused by the fungus Alternaria solani. The disease is rather poorly named since it usually occurs late in the season on plants which are approaching maturity.

Symptoms

Small, chocolate-brown to black angular spots occur first on lower, older leaves. They are usually bounded by leaf veins and often display

concentric rings like a target board. A yellow border sometimes surrounds the spots.

Disease Cycle

The causal fungus lives over winter principally in contaminated potato vines on or in the soil. When frequent rains or dews occur and temperatures are fairly high, the fungus produces millions of microscopic spores which are blown by air currents, splashed by rain, or carried by insects to the leaves of healthy plants. Here they germinate and penetrate the tissues in the presence of moisture and warm temperatures (60-90°F). Spots develop as a result of the activity of the fungus within the leaf. More spores are produced on the spots and these in turn are spread to neighboring plants. Many such cycles occur if weather remains warm and moist, causing extensive blighting of foliage.

Characteristic Leaf Spots of Early Blight (Note the target board pattern and how the spots are delimited by leaf veins.)

Damage

The principal effects of early blight are premature death of leaves and subsequent yield loss. Tuber infection is rare in New York State. In addition to potato, the disease affects tomato, eggplant and weeds in the nightshade family.

Late Blight of Potato

Late blight is caused by the fungus Phytophthora infestans which affects tomatoes and other members of the "nightshade" family in addition to potatoes.

Symptoms

Characteristic spots on leaves are brownish to purplish-black in color and are usually surrounded by a pale green, watersoaked zone which blends into the healthy tissue. Spots on stems and leaf stalks appear as irregular dark brown blotches. Under moist conditions, especially in the early morning, a ring of white mildew growth can be seen on the undersurface margins of the leaf spots. This is the "give-away" symptom of the disease. Infected tubers show irregular surface depressions beneath purplish-black discolored skin. A shallow, brown, granular rot usually extends no more than 1/2 inch into the tuber tissue.

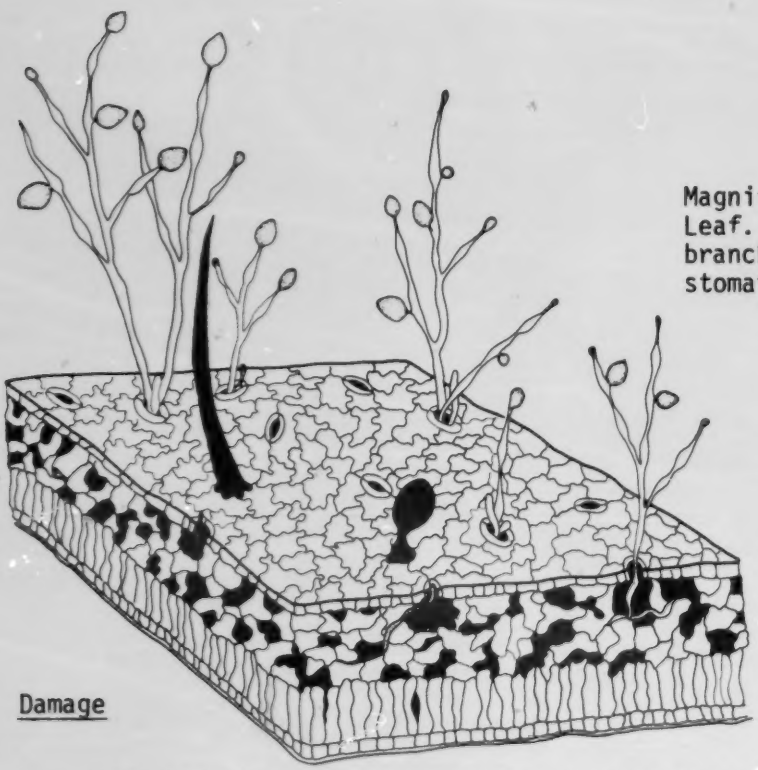
Undersurface of Leaf Infected with Late Blight. (Note the ring of white "fuzz" around the killed tissue.)

External and Internal View of Tubers Affected with Late Blight. (Note the metallic sheen on the skin and the dry granular nature of the rot.)

Disease Cycle

The causal fungus of late blight is carried over from season to season only in tubers (pickouts, volunteers, seed). It does not survive in soil-borne debris as in the case of early blight. When tubers renew growth in

the spring, Phytophthora infestans invades a few sprouts and grows within the tissues of the developing potato plant. Later,during moist weather, specialized spore-bearing branches grow out of the stomata of the leaves and stem. Spores produced on these branches are blown by wind to healthy plants nearby. If free moisture is present, they germinate and invade the leaf or stem tissues. After approximately 5 to 7 days, a blight spot develops and around its margin and new "crop" of spores is produced under conditions of high relative humidity. These in turn are blown to neighboring plants to initiate a new disease cycle. Warm days and cool nights with abundant dew favor and reproduction of the late blight fungus and allow for more and more disease cycles. Tuber infection results from spores being washed by rain or irrigation from leaves onto tubers in the soil.



Magnified View of a Potato Leaf. (Note spore-bearing branches protruding through stomates.)

Damage

Late blight is an extremely "explosive" disease which spreads very rapidly under favorable conditions and can cause drastic defoliation and serious tuber rotting with subsequent loss in storage.

Potato Leaf Roll

Potato leaf roll is caused by a tuber-borne virus which is transmitted by several species of aphids, the most important of which is the green peach aphid.

Typical Symptoms of Secondary Leaf Roll. (Note inward rolling and cupping of leaflets)

Net Necrosis (A symptom of primary or current season leaf roll)

Symptoms

Two kinds of leaf roll can be distinguished in the field - secondary (also called "chronic" or "seed-borne") and primary (also called "current season"). Secondary leaf roll, which is the first to appear and arises from virus-infected tubers, is characterized by inward rolling and cupping

of leaflets, starting with lower leaves and progressing upward in the plant. Leaflets are thickened, leathery, and stiff, and rattle when the plant is shaken. Affected plants are dwarfed, yellowish-green, and erect. Symptoms of primary leaf roll are visible only when infection takes place early in the season. The leaflets of upper leaves roll inward and are often discolored reddish-purple. In certain varieties, primary leaf roll produces a condition known as net necrosis in tubers. Dark brown strands extend through the internal tissue, particularly at the stem end.

Disease Cycle

Tubers from plants with primary or secondary leaf roll are usually infected with the causal virus, even though internal symptoms may not be visible. When planted, they give rise to secondary leaf roll early in the season. Aphids feeding on infected plants acquire the virus and subsequently transmit it to healthy plants as they continue to feed. Primary leaf roll symptoms usually appear about two weeks after aphid feeding on secondary leaf roll-infected plants.

Damage

The disease causes serious yield reductions and is the most important cause for rejection of certified seed. In certain varieties, tuber quality is also reduced by leaf roll.

Summary - Some Diseases of Vegetables and Potatoes

Name of Pest	Type of Injury	Plant Attacked	Plant Parts Attacked	Infectual or Damaging Stage	Pest Recognition	Additional Favorable Conditions	Injury Diagnosis	Control Measures
Bacterial Blight (Beans)	Blotching and spotting	Beans	Stems Pods	Bacterial cell	See injury diagnosis	Rain Dew 65-85 F	Brown blotches with yellow rings around them in leaves. Wet spots with exudate in pods	Chemical: Spray at first symptoms then 7-10 days later.
Downy Mildew	Discolors foliage	Cabbage Cucurbits Lettuce	Leaves	Spores	See injury diagnosis	Wet weather 61-72 F High humidity Warm nights	Pale or yellowish leaf spot whose lower face has a whitish or purple mold. Leaves turn yellow on cabbage.	Chemical: Spray beginning at 2-3 leaf stage; then every 5 days.
Early Blight	Necrotic spots	Tomato Potato	Leaves Fruit Tubers	Spores carried by wind and rain	See injury diagnosis	Wet leaves 75-85 F	Target spots on lower leaves progress upward. Lower leaves dry up and droop. Fruit or tubers rot.	Chemical: Apply weekly sprays in mid-season. Cultural: Rotate crops.
Late Blight	Discolors foliage. Necrotic spots	Tomato Potato	Leaves Stems Fruits Tubers	Spores	See injury diagnosis	Cool nights Warm days Dew	Grey water soaked spots surrounded by a pale border White fungus growth on the underside of the leaf at lesion border Hard corky brown rot below surface of fruit or tubers.	Chemical: Strict fungicide spraying every 7 to 10 days mid-season to harvest. Cultural: A few tolerant varieties of potato and tomato are now available.

Summary (Cont'd.)

Name of Pest	Type of Injury	Plant Attacked	Plant Parts Attacked	Infectual or Damaging Stage	Pest Recognition	Additional Favorable Conditions	Injury Diagnosis	Control Measures
Onion Leaf Blight	Leafspotting Upper portions of leaves die.	Onion	Leaves	Spores	See injury diagnosis	Warm, humid weather	Leaf spots, brown blotches and lesions on leaves	Chemical: Apply fungicide every 7-10 days in mid-season.
Potato Leaf Roll	Leaf rolling	Potato	Leaves Tubers	Aphid-transmitted virus	See injury diagnosis		Upper leaves rolled, stems may show purple color. Net necrosis of tubers	Chemical: Disease spread by aphids; thus full season insecticides required.
Powdery Mildew of Cucurbits	Mildew on leaves and stems	Cucurbits	Leaves Stems	Spores	See injury diagnosis	Dry. 80-82 F	White powdery growth on leaves and stems causes them to dry up.	Chemical: Specific fungicides applied at first sign of mildew, then ten days later.
Sclerotinia White Mold of Beans	White mold	Beans	Stems Pods	Spores	See injury diagnosis	Warm, humid weather	White mold on stems may kill plant, mold on pods, black seeds in white mold.	Chemical: Fungicide spray at 10% and 100% bloom.
Tomato Anthracnose	Fruit spotted	Tomato	Fruit	Spores	See injury diagnosis	Optimum temperature 80°F	Sunken dime sized spots on fruit, rotting fruit No leaf symptoms	Chemical: Regular fungicide applications applied mid-season to harvest.

Some Weeds in Vegetables and Potatoes

Some of the weeds that frequently cause problems in vegetables and potatoes are listed. Pictures and descriptions of the weeds can be found in Chapter VIII on the pages noted.

	Page
Barnyardgrass	203
Foxtail	207
Galinsoga	208
Lambsquarters	210
Purslane (pussley)	213
Quackgrass	213
Redroot Pigweed	215
Yellow nutsedge	217

The Summary -- Some Weeds in Vegetables and Potatoes immediately following will give you quick information about the weeds listed.

Summary - Some Weeds in Vegetables and Potatoes

Name of Weed	Life Cycle	Brief Description	Environment Favoring	Control
Barnyardgrass	Annual grass	Stems tall, strong, erect, very virorous and somewhat succulent. Leaves smooth. Large, yellow-brown open seedhead.	High fertility and moisture and especially along ditches and in low spots in the field	Chemical: Preplant or preemergence. Cultural: Cultivation to kill germinating or very young seedling; drain wet areas. Mow or kill escapes before seed formation.
Foxtail	Warm season, annual grass	Smooth stem, short hairs on upper leaf surface, "foxtail" seedhead.	Warm, moist, fertile soil	Chemical: Preplant or preemergence Cultural: Cultivation.
Galinsoga	Annual broadleaf	Stems erect or spreading, branched. Leaves egg-shaped, pointed, thin, flower heads small, scattered. Ray flowers small, white, 4-5 in number, surrounding yellow disk flowers.	High fertility, weedy gardens, lowland fields, waste places, especially in damp areas	Chemical: Preplant or early post-emergence. Cultural: Early, frequent shallow cultivation.
Lambsquarters	Annual broadleaf	Stems erect, angular or ridged, hairless. Leaves alternate, simple, greyish green or silvery below. Flowers greenish; seed black, shiny, lens-shaped.	High fertility, good moisture but can tolerate drought. Cultivated areas.	Chemical: Preemergence or early postemergence. Cultural: Early frequent shallow cultivation to kill germinating seed and young seedlings.
Pigweed (Redroot)	Annual broadleaf	Stems rough and hairy. Leaves alternate and simple with long petioles. Seedhead dense and bristly. Lower stem and root red in color.	High fertility, good moisture, cultivated areas.	Chemical: Preferably preemergence--germinating seed. Cultural: Early, shallow, frequent cultivation to prevent seedling establishment.
Purslane (Pussley)	Annual broadleaf Warm season	Stems smooth, succulent, red in color. Leaves thick and fleshy. Plants lie flat or prostrate in mats. Small yellow flowers.	High fertility, good moisture cultivated open areas.	Chemical: Preemergence or early postemergence. Cultural: Frequent, shallow cultivation--late into the season if possible. Large established plants difficult to kill.

Summary (Cont'd.)

Name of Weed	Life Cycle	Brief Description	Environment Favoring	Control
Quackgrass	Perennial grass Cool season	Stems erect from wiry underground jointed rootstocks. Leaves flat, narrow, rough on upper surface. Heads or spikes flat with two rows of seeds on opposite sides of the axis.	High fertility and good moisture but is also highly persistent and adaptable to other conditions.	Chemical: Prior to planting crop and pre or post emergence to the weed. Cultural: Plowing, clean cultivation, deep tillage in the fall to expose rootstocks.
Yellow Nutsedge	Perennial sedge Warm season	Stems erect, triangular, yellow-green. Leaves grass-like. Heads flat, light brown. Produces underground tubers 0.5" diameter, dark brown in color.	High fertility and moisture but widely adaptable; especially if other weeds absent or low in number.	Chemical: Incorporate preemergence or while seedling still very small. Primary source of infestation is from the nuts or tubers. Cultural: Clean cultivation.

V. FIELD AND FORAGE CROP PESTS

Special Problems

Drift is the principal problem that is common to commercial applicators working in field and forage crops. 2,4-D and related compounds are commonly used in treating field and forage crops and small amounts drifting to neighboring crops, vegetable gardens and ornamentals may cause either illegal residues or phytoxicity or both. Paraquat is widely used as a part of no-till corn culture and small amounts drifting to neighboring fields cause highly noticeable phytotoxicity, particularly if the field belongs to someone else. Usually the applications are low volume with many fine droplets and are applied in the spring when it is often windy and difficult to work under good conditions. Be sure you know what is downwind on the other side of the hedgerow.

Fences surrounding the treated area must be in good condition so that domestic animals cannot break in and graze on recently treated forage or crops. You may wish to use less toxic insecticides that are registered for hay and pasture if you have a choice and fences are poor. Wilting leaves of treated brush growing in pastures sometimes become attractive to grazing animals. Cherry leaves when wilted contain a cyanide derivative that may be fatal to grazing livestock. It is up to you to alert the owner to these risks if you apply herbicides where grazing animals may be threatened.

Pollinators also are a problem. Alfalfa should not be sprayed when in bloom and you can usually avoid doing so. Some states have laws forbidding application to a crop in bloom. However, if the alfalfa is weedy the weeds may bloom and attract honey bees and other pollinators. Timely spraying in the early morning or just before dusk will reduce this problem. You may be able to encourage the use of herbicides in subsequent plantings so that bloom from weeds is no longer a problem.

Where making applications directly to feed or forage crops you must make sure that the pesticide used is fully registered for the use involved. In this manner illegal residues in meat and milk or poisoning of animals can

be avoided. Some highly toxic insecticides are used to treat field and forage crops and label instructions must be heeded, including those that apply to safety for the applicator. Be sure that the owner of the crop you spray is aware of feeding or grazing limitations and the harvest interval, if there is any.

One of the most widely used pesticides in the northeast is the herbicide atrazine. This material is used principally on corn and sorghum. Atrazine is of little hazard to the applicator and is not generally a hazard to wildlife. However, it is persistent and may injure sensitive crops planted too soon on the same area after the corn or sorghum is harvested. The labeling gives the times that must be observed before planting a different crop.

Atrazine plus oil is recommended in postemergence treatments to provide quicker kill of weeds. However, it is possible to cause severe damage to corn or sorghum if unsuitable oil or contaminated sprayers are used. Pay close attention to the procedures outlined on the label.

You must be careful not to leave puddles, let nozzles drip on pasture or drift pesticides to hay or pasture land. If livestock gets sick for any reason soon after you have sprayed, you will be suspected, so your application technique must not be faulty.

In some areas runoff from cultivated fields is a problem. You can suggest to your client that he reduce runoff by leaving a sodded buffer area between the field crops and water. Also your client may wish to consider planting crops using safer pesticides near sensitive areas.

Application Methods and Equipment

Low pressure boom sprayers are most commonly used in application of liquid pesticides to field and forage crops. High pressure boom sprayers may be used but with the pressure lowered so that they are classed as low pressure sprayers. The boomless sprayer, a variation of the low pressure boom sprayer, may also find some use and airblast equpment using concentrated sprays is also occasionally used. Dry applications are made with granular equipment, and agricultural aircraft are used for both wet and dry applications.

The following outline refers you to the appropriate pages in Chapter III:

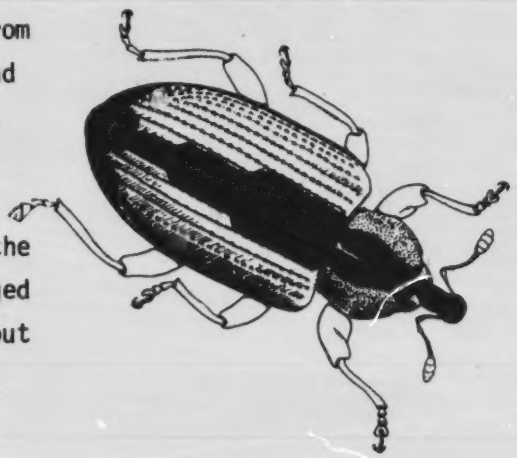
Sprayers	Page
Boom Sprayers - Low Pressure and High Pressure	53
Boomless	53
Airblast (Row Crop)	60
Granular Application Equipment	
Granular Band and Broadcast Applicators	67
Aerial Application	75

Some Insects of Field and Forage Crops

Alfalfa Weevil

Description

This insect was originally described in the United States from Salt Lake City, Utah in 1904. The infestation spread in the western states but it was not until 1952 that the alfalfa weevil was found in the East. It spread rapidly from the first eastern infestation in Maryland and now occurs throughout the northeast.



The adult weevil is greyish brown with a tapering dark brown stripe down the center of the back. Weevils newly emerged from the pupal stage, are tan in color but darken up as the color scales are lost from their bodies. Adult weevils are about 1/8 inch long.

The larva (worm) is nearly 1/2 inch long and has a green body with a wide white stripe and two fine white stripes down the middle of its back. It has a distinct head which is black or dark brown in color. The very young larvae

are pale and dirty yellow. When larvae are mature, they spin net-like cocoons in which to pupate. The white cocoons are attached along the alfalfa stems, on the leaves, or at the base of the plant.

Life Cycle

This weevil winters in the adult stage. Farther south, adults, and also some eggs, overwinter. In the spring, adults return to the alfalfa fields from overwintering sites in nearby woods and hedgerows. Egg laying starts in early May and continues until early June. Each female may lay 600 to 800 eggs. during the spring. The female weevil cuts a hole in the alfalfa stem and lays its eggs inside the stem. Eggs, when first laid, are yellow but before hatching they turn to a dark greyish color. Larval development takes about 21 days depending on the temperature. Most larvae become full grown about the time of cutting of the first crop. When mature, larvae spin cocoons and in about 10 days become adults. Adults leave the hot dry fields in July and do not return until the next spring. There is only one generation per year.

Damage

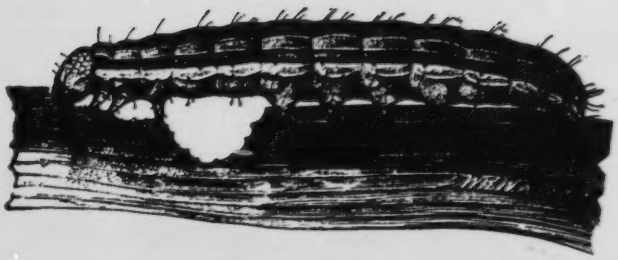
Both the adults and larvae with chewing mouth parts feed on the top leaves, buds and young shoots of alfalfa. The leaves are skeletonized and young buds are often completely destroyed. The injured leaves dry up giving the field a greyish, white cast much like that caused by frost. This type of injury is noticed most often on the first cutting. The larvae, when young, like to feed in the tightly folded leaf tips.

After the first crop of alfalfa has been cut, the larvae crawl to the new shoots of the second crop and continue feeding. They retard new growth and may seriously damage the second crop. The new adults also damage the new shoots.

This insect prefers alfalfa on which it is very destructive but it will also feed on clover, and a few other plants.

Armyworm

Description



The armyworm is the caterpillar stage of a night flying moth having a wingspan of 1-1/2 to 1-3/4 inches. The moths are greyish-brown with a small silver-white dot on the center of each forewing. These moths are seldom recognized by most people as they fly at night and hide in the day.

The larvae (caterpillars) which hatch from eggs laid on grasses mature in 21 to 28 days. The full grown larva is a nearly naked, smooth, striped caterpillar about 1-1/2 inches long. Its general color is usually greenish to reddish brown, and the stripes, one along each side and a broad one down the center of the back are dark and often nearly black. When the full grown caterpillar ceases feeding, it usually burrows into the ground, forms an earthen cell and pupates.

Eggs are deposited in masses or rows on the stems and leaves of grasses and resemble small white beads, each considerably smaller than a pinhead.

Life Cycle

Adult moths are active as early as late March. Eggs for the most destructive generation are laid in early summer. The adults seek out thickly planted areas of grasses or grasslike grains such as oats and wheat upon which to lay their eggs. From these eggs hatch little caterpillars which feed and grow rapidly.

When full grown the caterpillars transform to pupae. The moths which emerge lay eggs for a second generation. There are usually three broods of caterpillars in any one year, but seldom two successive outbreaks in any given locatility. The first generation is usually the most destructive.

Damage

This insect prefers grasses, small grains, and corn upon which to feed. The armyworm caterpillar has chewing mouthparts and injures crops by eating the tender parts of the leaves, the immature seed, and the sprouts, and when numerous, it may even devour the whole plant. During heavy armyworm outbreaks corn plants as tall as 8 to 12 inches high may be completely eaten. The more important and by far the most conspicuous injury is always inflicted by the nearly full grown caterpillar, whose greed and capacity for food are almost unbelievable. The pupa does not feed. The adult moth survives on nectar gathered from flowers.

Cereal Leaf Beetle

Description

This is an insect recently introduced into the United States. It was first found in Michigan in 1962 and in western New York in 1969. It has spread slowly eastward during the past eight years and is now found in most New York State counties. This insect is a pest of small grain crops, especially oats, wheat, and barley.

The adult of the cereal leaf beetle is about 3/16 inch long. Its wing covers and head are a metallic, bluish-black. The legs and front segment of the body are reddish in color. The male of the species is slightly smaller and narrower than the female and these smaller sized adults are easily distinguished when one examines a collection of adults.

The eggs are less than 1/16 inch long and yellow in color when first laid, but darken to almost black before hatching.

The larva is slightly larger than the adult. Its head and legs are brownish-black, and the body is yellow. In the field, the larvae look like shiny black globules on the upper surface of the leaves. They pile fecal matter on their backs in an effort to escape from predators such as birds.

Life Cycle

Overwintered adults of the cereal leaf beetle fly to the grain fields in the spring. Mating takes place and the female lays eggs on small grains and related grasses. The eggs are laid singly, rarely with more than two or three laid end to end, on the upper surface of small grain and grass leaves. Larvae, which hatch from the eggs, complete their feeding after about 21 days and pupate in the soil. There is only one generation per year. Summer adults emerge and feed until fall. They then hibernate in grain stubble, under field trash and in adjacent woodlands and hedgerows until the following spring.

Natural spread of the beetle occurs during the adult stage when dispersal flights take place. This insect has spread rapidly eastward from its original site of introduction, indicating that it is carried with the prevailing winds.

Damage

Both adults and larvae of the cereal leaf beetle damage grain crops. The adults eat longitudinal slits between the veins and completely through the leaves. The larvae eat only the outer upper surface of the leaves giving them a frosted appearance. When heavy feeding damage occurs, the grain yield of the crop is reduced.

Corn Leaf Aphid

Description

The corn leaf aphid is a small bodied dark greenish-blue aphid which colonizes on corn tassles and in the whorl. This insect is soft-bodied and about 1/16 inch long. There may be a few winged forms present in

a colony but usually one sees only the wingless forms in large numbers.

Life Cycle

This aphid is found early in the spring (mid-May) on corn in the Hudson Valley. It is assumed it passes the winter as an egg in New York State. Once established in the spring, several generations are produced each year. Generations overlap so it is impossible to identify a particular generation. The higher the temperature and humidity, the more abundant and troublesome this aphid becomes.

Damage

The corn leaf aphid has sucking mouth parts. When present in large numbers, yield losses result from the heavy feeding stresses on the plant. A residue (honeydew) which is excreted from the insect, contains large amounts of carbohydrates. This sticks to the leaves and ear flag leaves below the colony. A black sooty fungus grows on the honeydew producing a very sticky, unsightly situation.

This insect also carries and transmits the disease maise dwarf mosaic which affects both field and sweet corn.

European Corn Borer

Description

The insect was accidentally introduced into the United States around 1908 on imported broomcorn. For many years, attempts were made unsuccessfully to restrict the insect from getting in the corn belt of the central United States.

Few insects have attracted more attention than the European corn borer. As its name implies, it is a native of Europe where it has long been a serious enemy of corn, especially in Central Europe.

In New York State corn is the main host plant of this insect, but many other plants may be attacked. The adult female is a yellowish-brown moth with irregular dark lines in geometric patterns across the wings. The male is slightly smaller and more heavily marked with darker brown. The moths have a wingspan of about one inch.

The larva or borer is dirty-white and about one inch long when fully grown.

Life Cycle

The borer larvae overwinter in their burrows in corn stalks or weeds. All of New York State, except the extreme northern and Adirondack counties, has the two brooded strain of this insect. Larvae pupate in their overwintering quarters in May, and by May 20-30 (Geneva) the moths start to emerge. These moths lay flattened eggs in an overlapping scale-like mass containing 15-20 eggs on the undersides of the leaves. Most larval invasion of the plants takes place in the whorl stage.

First brood worm activity is at its peak in June. The second brood worms are particularly troublesome in the ears and stalks during August in most of the state. The second brood borers start their damage later in August upstate so will continue their feeding into September.

Damage

Corn is the main crop damaged, but the borer has a wide range of host plants which include both cultivated plants and weeds. On some of these plants the insect is capable of passing through all its stages, while ohers afford only temporary shelter and food. Some of the more important cultivated plants which have been found infested, in addition to corn, are lima beans, snap beans, beets, eggplant, Swiss chard, peppers and potatoes. Potatoes form an important link in the life history of the insect on Long Island, since a large number of the borers of the first brood mature in the vines of this crop. Some of the weeds which are commonly infested are dock, smartweed, ragweed, barnyard grass, and pigweed.

The major damage caused by this insect to field corn is to the stalks. Borers tunnel down the stalk from the tassle to within 6" of the soil. In years of heavy infestations, borers may be so numerous that severe stalk damage occurs causing the stalks to bend or break over making machine harvest impossible. Corn for silage does not usually suffer as severe damage as grain corn because it is harvested earlier. The weakened stalks of corn for grain often breaks over or off at the ear level, causing a serious loss of crop.

Meadow Spittlebug

Description

The springtime presence of masses of white froth, or spittle on the leaves and stems of alfalfa, clover and birds-foot trefoil indicates activity of the meadow spittlebug. The adult spittlebug resembles a leafhopper but is larger and much stouter. There are at least four color variations to the adult meadow spittlebug. Their color may range from shades of tan to dark brown, to nearly black. The adult is broadly wedge-shaped and about 1/4 inch in length. The nymph or immature stage spends nearly all its developmental stages within the spittle mass. The young spittlebug soon after hatching, secretes a liquid that is mostly plant sap obtained through its sucking mouth parts. It forces air through the liquid in such a way as to produce the spittle. Enveloped by the spittle, it lives in the crowns or folded leaves of alfalfa, clover or trefoil and sucks the plant juices.

Life Cycle

The winter is spent in the egg stage, nymphs develop in the spring within the spittle mass and adults emerge in June. There is one generation per year. The eggs are laid under the leaf sheath of small grains in the fall. The following spring, in late April or early May, eggs hatch and the nymphs establish themselves on suitable forage crop host plants. The nymphal period lasts 5-8 weeks depending on temperature. Adult spittlebugs will remain in the fields as long as succulent foliage is available. By early September, the females lay compact rows (containing 1 to 20 eggs) in grain stubble or old plant stems. Egg laying continues until the females die naturally or are killed by severe frost. There is one generation per year.

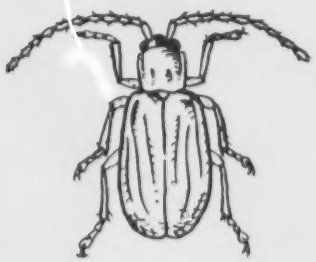
Damage

Almost all spittlebug damage is done by the immature insects which have sucking mouth parts. By sucking away the juices of alfalfa, clover or birdsfoot trefoil, the nymphs stunt the plants and reduce the yield of forage. When very abundant on alfalfa, they cause a resetting of the terminal growth. Hay yields may be reduced by 25 or more percent. Because these insects suck plant juices, more damage is caused if April and May are dry than if these months are unusually wet.

Northern Corn Rootworm

Description

The adult of the Northern corn rootworm is a beetle. The beetle is nearly 1/4 inch long and of a uniformly pale green or yellowish green color. Adults are very active and when disturbed tumble out of corn silks or off flowers where they may be feeding. The larva is a thread-like white worm which reaches 1/2 inch in length with a yellow-brown



head and six small legs. It has well developed mandibles for chewing and tunneling inside of corn roots. Eggs are small, white and laid singly in the soil around the base of corn plants.

Life Cycle

This insect overwinters in the egg stage. In early to mid-June eggs hatch and the young larvae travel through the soil until they reach corn roots. Larvae cut off the smaller roots and tunnel in the larger roots causing the plant to lack vitality and in severe cases to fall over.

Larval development is completed by mid-July when the insect pupates. In a few days adults emerge. The newly emerged callow adults are a dusky transparent grey color. In a few days they acquire the characteristic pale green color.

Adults feed on corn silks, and the pollen of corn and many other plants. The eggs are deposited in corn fields during August and September. All the beetles die at the time of killing frosts.

Damage

This insect in its immature form feeds on the roots of corn. The adult feeds on corn silks. When adults are plentiful in mid-August they may feed so severely on corn silks that the ears do not fill properly. Larvae feed on developing corn root systems during June and July causing plants to fall over. This insect is most severe where corn is planted after corn for three or more consecutive years allowing the population to increase each year until severe corn root damage results.

Potato Leafhopper

Description

Small, green jumping insects associated with yellow, stunted alfalfa occur each year. The insect involved is the potato leafhopper.

The adult potato leafhopper is a pale, pea-green, wedge-shaped, sucking insect about one-eighth inch long. The nymph or immature leafhopper is yellow to a yellowish-green color. Both the adults and nymphs run sideways or backward very rapidly and usually try to keep on the underside of a leaf as it is turned over.

The insect does not overwinter in the northern United States, but only in the extreme southern fringe of the deep south or possibly Mexico. Each year the New York infestations on alfalfa and red clover are the result of migratory flights from areas to the south. The insect moves northward from its over-wintering quarters with the warm spring winds and weather systems. It usually arrives in Central New York in early June.

Life Cycle

When adult potato leafhoppers arrive in New York they concentrate on vegetable crops such as beans and potatoes as well as alfalfa and red clover where they feed and lay eggs. The eggs are laid in the large veins and petioles of the plant leaves. The young hatch in about 10 days and are similar in shape to the adult but smaller and lighter in color. Under favorable conditions, the insect develops from egg to adult in about three weeks. In New York several overlapping generations are produced which overlap in the field and cannot be definitely distinguished. Adults and nymphs continue to feed on host crops until they are killed by severe fall frosts.

Damage

Nymphs and adults of the potato leafhopper have sucking mouthparts. This insect feeds on and damages many crops including beans, potatoes, alfalfa and red clover. When heavy populations of leafhoppers are present damage symptoms are expressed as a yellowing and stunting of the plant, especially second cutting alfalfa in July and August.

The plant reacts to leafhopper feeding. Various shades of pink, red, yellow and purple in a V-shape, beginning at the midrib of the leaf indicate leafhopper injury. Much of the loss from this insect occurs in injury to new seedings. Plants are killed and weeds crowd out the remaining alfalfa or red clover. The most severe injury occurs during hot, dry mid-summer weather when the plant is already under moisture stress.

Field and Forage Diseases

The principal approaches to diseases of field and forage crops in the northeast are cultural management, use of resistant or tolerant varieties, and chemical seed treatment (handled in Category 4 training - "Seed Treatment"). Fungicide spraying to control certain leaf diseases has shown benefit in some experimental situations but is not yet recommended on a commercial scale.

Since the commercial pesticide applicator in the "Agricultural-Plant" category has very limited, if any, involvement in the control of this group of diseases, we have omitted them from this manual.

Some Weeds of Field and Forage Crops

There are many weeds of field and forage crops. Since some crops are cultivated in rows and others are broadcast and may last one season or several, chemical and cultural controls of the same weed vary from crop to crop. Some weeds listed are important in some crops and not in others. Some of the weeds that frequently cause problems are listed. Pictures and descriptions of these weeds can be found in Chapter VIII on the pages listed.

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Barnyardgrass	203
Bindweed (Field)	203
Crabgrass (Large)	205
Dandelion	206
Fall Panicum	207

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Horsenettle 210
Mustard (Wild) 212
Quackgrass 213
Ragweed (Common) 214
Redroot Pigweed 215
Shepherdspurse 215
Velvetleaf 216
Yellow Nutsedge 217
Yellow Rocket 217

The Summary - Some Weeds of Field and Forage Crops will give you quick information about the weeds listed.

Summary - Some Insects of Field and Forage Crops

Name of Pest	Type of Feeding	Plant Type Attacked	Plant Parts Attacked	Signs of Injury	Best Life Stage to Recognition of Insect	Control	Control Other
Alfalfa Weevil	Chewing	Alfalfa	Leaf	Chewing on leaves. Alfalfa field develops greyish color when heavily damaged.	Larva is a green worm with white stripe on back, nearly 1/2" long. Adult small snout beetle 1/8 inch long.	Adult larva	Chemical: Apply when 50% of plant tips have injury. Cultural: Parasites. Cut early before serious larval damage occurs.
Armyworm	Chewing	Corn Small grain	Leaf	Extensive chewing of leaves, espeically in whorl of corn	Larva is 1-1/2" long, greenish-black with 5 stripes	Larva	Chemical: Control necessary when larvae easy to find.
Cereal Leaf Beetle	Chewing	Oats Wheat Rye	Leaf	Chewing on leaves. Field develops a grey cast.	Adult is 3/16" long, metallic blue with reddish thorax and legs. Larva is yellowish.	Larva	Chemical: Control when one or more per stem. Cultural: Parasites.
Corn Aphids	Sucking	Corn	Tassel whorl	Sticky leaves and ears with black sooty fungus	Soft, small, greenish-blue insects	Adult Nymph	Chemical: Treat as necessary. Cultural: Some varieties less susceptible than others.
European Corn Borer	Chewing	Corn	Stalk Leaf Ear	Feeding on leaves, tunnels in stalk, stalks fall over	Larva is 1" long, and tan with brownish spots.	Larva	Chemical: Treat field corn if 75% of plants have feeding in whorl Cultural: Plow fields in fall.

Summary (Cont'd.)

Name of Pest	Type of Feeding	Plant Type Attacked	Plant Parts Attacked	Signs of Injury	Best Life Stage to Recognition of Insect	Control	Control Other
Meadow Spittlebug	Sucking	Alfalfa Clover Birdsfoot trefoil	Stems	Stunted plants, white, frothy spittle masses on stems	Nymph is yellow to greenish lives inside of spittle mass.	Nymph	Chemical: Apply when first spittle masses seen if heavy infestation.
Northern Corn Rootworm	Chewing	Corn	Root system	Weakened roots allow plant to fall over and cause "gooseneck", loss of vigor and yield.	Adult is 1/4" long, green, feeds on silks. Larva white 1/2" long, feeds on roots.	Larva	Chemical: Treat 3rd year corn if damage previous year. Cultural: Rotate out of corn for one year when population is building up.
Potato Leafhopper	Sucking	Alfalfa Clovers	Leaf	Stunted, yellowed plants - red on leaves	Nymph is pea green, walks sideways, hops away.	Adult Nymph	Chemical: Treat second cutting at 6" stage if necessary Cultural: Plant varieties with some resistance.

Summary - Some Weeds of Field and Forage Crops

Name of Weed	Life Cycle	Brief Description	Reproduces by	Environment Favoring	Time and Type of Control
Barnyardgrass	Summer annual grass	Stems 1-4 feet tall; leaves smooth, light green, 3/8 - 5/8 inches wide. Seed head bearded, green or purplish.	Seed only	Rich moist soil	Chemical: Usually preplant or preemergence. Cultural: Cultivation, use of black plastic in vegetable crops.
Bindweed (field)	Perennial broad-leaf	Deep rooted creeping vine with small bell-like flower Arrowhead shaped leaves.	Seed Creeping root-stocks	Rich moist soil	Chemical: Postemergence or fallow application. Cultural: Multiple tillage.
Crabgrass (Large)	Summer annual grass	Stems stout smooth up to 3 feet long, recumbent, radiating out from central crown. Roots form at joints of stems. Hairy stem and leaves, finger-like seed head.	Seed	Germinates late. Grows well under hot, dry conditions.	Chemical: Preplant or preemergence. Cultural: Cultivation.
Dandelion	Perennial broadleaf	Deep rooted. Tooth-shaped leaves forming rosette growing close to soil. Flowers large yellow. Feathery seeds easily carried by wind.	Seed Shoots from roots	Numerous. Grows in almost any soil	Chemical: Preplant in alfalfa, pre- or post-emergence in row crops depending on crop. Cultural: Cultivation.
Fall Panicum	Annual grass	Stems erect or spreading, bent at the joints at the base of the plant; leaf blades narrow and lance-shaped.	Seed	Low moist areas	Chemical: Pre- or postemergence depending on crop. Cultural: Cultivation.
Horsenettle	Perennial broad-leaf	Stems are simple or branched 1-4 feet tall. Alternate leaves, yellow prickles on stem, midrib and veins. Flowers white or bluish. 5 lobed, 1 inch across. Berries soft, juicy, yellow.	Seed Creeping rootstocks	Sandy soil	Chemical: Postemergence in corn. Cultural: Cultivation

Summary (Cont'd.)

Name of Weed	Life Cycle	Brief Description	Reproduces by	Environment Favoring	Time and Type of Control
Mustard (Wild)	Annual or winter annual broadleaf	Stems erect, branched near top, with a few bristly hairs. Lower leaves lobed with bristly hairs, upper leaves smaller, smoother, more regular. Yellow flowers in clusters.	Seed	Cool, moist soil	Chemical: Early postemergence. Cultural: Cultivation in row crops.
Quackgrass	Cool season, perennial grass	Heavy matted underground roots (rhizomes). Leaves 3-12 inches long, 1/8 to 3/4 inch wide, sharply pointed, hairy above, smooth below. Seed head slender, resembles wheat.	Seed Creeping rootstocks	Cool, moist soil	Chemical: Preplow followed by preemergence. Cultural: Mechanical control is necessary with chemical.
Ragweed (Common)	Annual broad-leaf	Shallow rooted. Stems rough, hairy, erect, branching, 1-4 feet tall. Leaves mostly alternate deeply cut into lobes. Male flowers in clusters at tips of branches.	Seed	Well drained soils	Chemical: Pre-or postemergence. Cultural: Cultivation.
Redroot Pigweed	Summer annual broadleaf	Shallow bulbous, red-colored taproot, stem erect, to 6 feet tall, rough, branch freely. Green flowers clustered at branch tips and upper leaf axils.	Seed	Warm, moist fertile soil	Chemical: Pre- or postemergence. Cultural: Cultivation.

Summary (Cont'd.)

Name of Weed	Life Cycle	Brief Description	Reproduces by	Environment Favoring	Time and Type of Control
Shepherdspurse	Annual or winter annual broadleaf	Branched taproot. Erect, branched stems to 1-1/2 feet tall, covered with grey hairs. 2 to 4 inch leaves in rosettes at base of stem. Flowers small, white in elongate groups along stem. Seeds triangular.	Seed	Many	Chemical: Pre- or postemergence. Cultural: Cultivation.
Velvetleaf	Annual broadleaf	Strong taproot. Velvety, heart-shaped leaves. 6 to 8 feet tall. Yellow flowers on upper part of stem.	Seed	Warm, moist soil	Chemical: Pre- or postemergence. Cultural: Cultivation.
Yellow Nutsedge	Warm season perennial sedge	Roots fibrous with nut-like tubers. Stems erect, yellow-green and triangular in cross-section. Leaves narrow grass-like, in 3 rows.	Seeds Tubers	Low, damp soils	Chemical: Difficult to control pre- or postemergence. Cultural: Cultivation.
Yellow Rocket (Winter cress)	Short-lived, cool season perennial	Taproot, numerous erect stems. Stems to 2 feet tall, growing from crown or dense rosette. Flowers spike-like, bright yellow.	Seeds New shoots from old crown.	Rich soils	Chemical: Early postemergence. Cultural: Plowing.

VI. TREE FRUIT, VINE AND SMALL FRUIT PESTS

Special Problems

-- Tree Fruit. Tree fruits present some problems to you, the commercial applicator, that need your special attention. Because most of the equipment used is of the air-blast type using air to carry the pesticide into the tree it is more apt to cause drift than other ground application equipment. The drift problem is further increased by the use of low-volume concentrate sprays. Low volume equipment utilizes small droplets to obtain greater distribution but also is more subject to drift. The higher concentration of pesticides used adds to the importance of this drift and its possible harm. Those spraying orchards and trees should be particularly aware and careful of drift problems along property lines adjoining houses, pastures, hay fields, bee yards or colonies, streams, ponds and roads to avoid contamination of the areas by harmful residues and/or to avoid phytotoxicity. Sometimes it may be desirable to use a safer material if the job cannot be done when the wind is blowing from these areas.

Avoid drifting pesticides onto yourself. Wear adequate clean protective clothing as needed. Do not mix oil with highly toxic pesticides because oils evaporate slowly. This type of mixture adds even further to the problem of drift and applicator safety and should be avoided. Similarly, when highly toxic materials are being used, the practice of spraying from inside the tree to the outside should be avoided.

Phytotoxicity or spray injury is also a problem needing your continuous attention. There is a great difference in response among varieties as well as among different fruits. Poor fruit finish is often the result of chemical injury. To avoid injury do not spray before and after periods of low temperature and freezing; or at temperatures of 90°F or above. Some materials such as sulfur should not be applied above 85°F. Copper sprays in early season may also cause injury.

Avoid spraying crops in bloom with insecticides whenever possible because of toxicity to bees and other pollinating insects. Some states prohibit spraying during bloom. Avoid also leaving puddles of spray material or contaminated water as this can be highly toxic to bees foraging for water.

If you apply any of the 12 insecticides calling for either a 24 or 48 hour reentry period (see page 7), be sure that your client knows the situation. Otherwise workers may be illegallly exposed if they reenter the treated area too soon. Be sure also that your client is familiar with the days to harvest limitations.

-- Vine and Small Fruits. You may feel that there is little in the way of special problems when working in vineyards and small fruits. However, some highly toxic insecticides are recommended for grapes, brambles, blueberries and strawberries. Consequently adequate precautions against poisoning yourself or your help by careless handling or inadequate protective clothing and equipment which may be pesticide-soiled must be taken. Many vineyard owners use airblast equipment with low volume, fine droplet concentrate sprays. These are subject to drift and because of their concentration are more toxic than dilute sprays. You should be particularly aware and careful of drift problems along property lines adjoining houses, pastures, hay fields, bee yards, streams, ponds and roads. Avoid contamination of these areas by harmful residues and/or phytotoxicity. You may use a safer material if the job cannot be done when the wind is blowing away from these sensitive areas.

Avoid drifting pesticides onto yourself. High concentrate spray droplets and close quarters when moving between vines or among brambles may expose you to highly toxic pesticides. Protect yourself by using the proper clothing and equipment, both when mixing and applying pesticides to vines or small fruit.

If you apply any of the 12 insecticides requiring either a 24 or 48 hour reentry period (see page 7), be sure that your client knows the situation. Otherwise, workers may be illegally exposed when cultivating or harvesting. Be sure also that your client is familiar with the days to harvest limitations.

Vineyard owners have sometimes been blamed for pesticide pollution of the lakes that lie in the drainage of the hillsides and slopes on which grapes are commonly grown. Care in application so that streams running through the treated area are not contaminated is important. Terracing or sod strips may help reduce surface runoff. It is equally important to be aware of drainage when grub treating plowed sod before planting strawberries.

Application Methods and Equipment

Application equipment commonly used for treating tree fruits includes both airblast and conventional high pressure hydraulic sprayers, agricultural aircraft and equipment for soil fumigation prior to planting trees.

Equipment commonly used for vines and small fruit includes airblast; conventional high pressure hydraulic, both boom and hose and gun, and low pressure boom and directed sprayers. In vineyards the booms are usually modified to adapt to the trellises and airblast equipment is low mounted and narrow. The following outline refers you to the appropriate pages in Chapter III.

Sprayers	Page
High Pressure Hydraulic	
Boom Sprayers	53
Hand Gun and Hose	59
Airblast	60
Soil Fumigation	70
Aerial Application	75

Some Insects of Tree Fruit, Vine and Small Fruit

Aphids

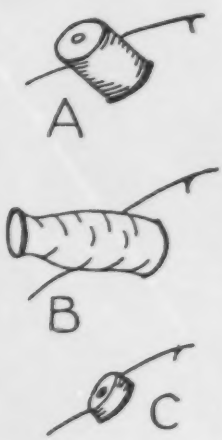
Several species of aphids infest and injure various fruit crops in New York State. Three species that are commercial pests primarily on apples and/or

pears--the rosy apple aphid, the green apple aphid and the grain aphid--will be discussed. These aphids acquire food by sucking juices from leaves and fruit.

Description

-- Apple Grain Aphid. The newly hatched aphids are dark yellowish green and may be distinguished under a strong lens by the cornicles on the abdomen which are short and appear like low tubercles as shown in the illustration. The adults are yellowish-green with darker bands across the abdomen.

-- Rosy Apple Aphid. The newly hatched nymphs are very dark green and may be distinguished from other species by the long cornicles which are flanged at the tip. The mature aphids vary in color, but are usually of a dark bluish slate color and are covered by a waxy bloom or powder. The rosy aphid has the habit of clustering on the leaves of the fruit spurs and in the stems of young fruit as well as on the fruit itself.



Cornicles of Newly Hatched Aphids. A. apple aphid B. rosy aphid C. grain aphid

-- Green Apple Aphid. The cornicles are longer than those of the apple grain aphid, but there is a close resemblance between the two species. The adults are yellowish-green.

Life Cycles

All three species overwinter as shiny black elliptical eggs about 1/32 of an inch long on the twigs and branches of apple, pear and possibly other host plants. The grain aphid hatch just as the buds are showing green while the green and rosy aphids appear from one week to 10 days

later. In normal seasons all three species have hatched by the time the buds are in the 1/2 inch green stage. After hatching the three species differ in their life cycles as described below.

-- Apple Grain Aphid. The apple grain aphid is usually the most abundant species on the opening buds. The majority of the second generation acquire wings and migrate to grains or grasses where they live until October or November when winged males and females are produced. These return to the apple where the overwintering eggs are deposited.

-- Rosy Apple Aphid. The first and second generation rosy apple aphids habitually cluster on the leaves of the fruit spurs and in the stems of young fruit as well as on the fruit itself. The majority of the third and fourth generation develop wings and migrate to narrow leaved plantain where they live until fall when they return to apples to deposit the overwintering eggs.

-- Green Apple Aphid. The green apple aphid has several generations per year and usually remains on the fruit throughout the summer. In the fall winged adults are produced and overwintering eggs are deposited on apple, pear and possibly other deciduous trees.

Damage

-- The apple grain aphid feeds on apples for only a few weeks early in the spring without causing serious injury.

-- The rosy apple aphid is usually the most destructive aphid species to attack apples. It feeds on both the succulent leaves and on the fruit. Its feeding causes the leaves to crinkle and curl much more than the other two species while the fruit it attacks becomes so dwarfed and deformed that it is unmarketable and useless. This species is most destructive to Baldwin, Rhode Island Greening, Cortland, Rome, Jonathan, Maiden Blush, Twenty Ounce, and Northern Spy. Varieties such as McIntosh, Dutchess and Wealthy usually escape serious fruit injury.

Rosy Apple Aphid Injury to Leaves

Rosy Apple Aphid Injury to Fruit

-- The green apple aphid has a tendency to attack the tender growing terminals and the water sprouts of apple and pear. In addition to dwarfing the leaves and the shoots it attacks, it produces a large amount of honeydew which drips on the laves and fruit and serves as a substrate for the development of the sooty mold fungus. This aphid is also an important disseminator of the fire blight pathogen, carrying it from infected tissue to other succulent and susceptible terminals on the same or other trees.

Sooty Mold Fungus (Growing on honeydew produced by green apple aphid)

Apple Maggot

Description

The adult of the apple maggot is a black bodied fly slightly smaller than the house fly. The female is larger than the male and has four white bands across the abdomen while the male has only three. Markings roughly in the form of an inverted W on the wings of moth sexes help to differentiate this species from similar species.

The full grown maggot is about 3/5 of an inch long and white or yellowish-white in color.

Life Cycle

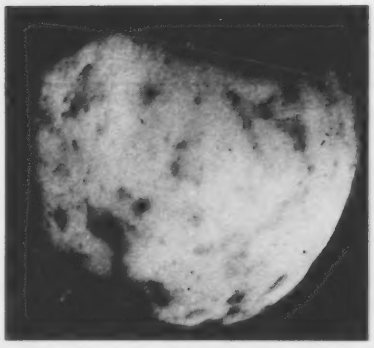
The flies begin to emerge from their over-wintering puparia in the ground during the last two weeks in June and continue to emerge until late August. Peak emergence usually occurs about mid-July. Oviposition is delayed for seven to 10 days after emergence.

The female deposits her minute whitish eggs singly beneath the epidermis and in the pulp of the apple. The eggs hatch in from four to six days, depending on the temperature, and the young maggots begin at once to tunnel through the fruit causing brownish trails. Often badly infested fruits fall to the ground early. The full grown maggot emerges from the fallen fruit and burrows into the soil to a depth of one or two inches. Here it changes to a pupa in a puparium where it spends the winter.

Damage

Throughout the Northeast the apple maggot is one of the most serious pests of apple and is present in many orchards. All apple varieties may be

attacked but late summer and early fall varieties are especially subject to injury. Late fall varieties are also attacked and may sustain considerable injury. However, larval survival in the firm flesh of these varieties is usually very low limiting the build up of heavy infestations. Greatest injury to these late fall varieties most often occurs when they are interplanted with early varieties where larval survival is high. The apple maggot also infests plums and prunes.

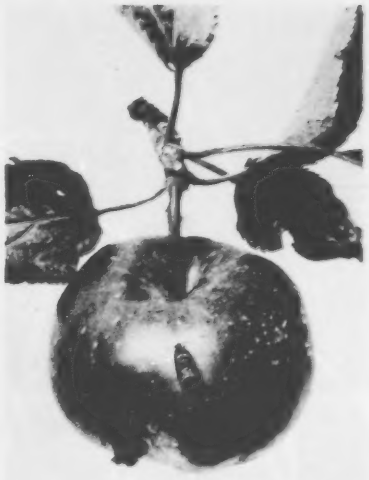


A large number of eggs may be deposited in a single fruit producing a much dimpled and pitted appearance as a result. Numerous tunnels reduce the inside of the apple to a brownish pulpy mass rendering it unmarketable. Even one or two maggots in a fruit significantly reduces its keeping qualities. Fall varieties in which eggs are laid late in the season may seem to be sound at picking time only to rot later as a result of the work of the maggots after the fruit has begun to soften in common storage. Since maggots end up as insect fragments in processed fruit, processors usually have a near zero tolerance for this pest.

Coddling Moth

Description

The adult moth has a wingspread of about 3/4 inch. The front wings are marked near the tip with a coppery-brown spot bounded on the inside



Frass at Point of Entry, Adult Moth, and Sting.

by a chocolate colored band. The moths are most active throughout the twilight periods on warm evenings. They are not strong flyers, the majority remaining within 200 to 300 feet of the place of emergence.

The larvae are pinkish or whitish in color and about 3/4 of an inch long when full grown. The head is dark brown.

Life Cycle

This insect passes the winter as a full grown larva in a tough silken cocoon which lines a small excavation beneath flakes of bark on the tree, in crotches, crevices and pruning scars on the trunk and in dead, punky twigs, sticks and other debris on the ground. Numbers of larvae also overwinter in the cracks and crevices in the floors and siding of packing houses, cider mills, bins and crates, or other places where infested apples have been stored after picking. The larvae are pinkish or whitish in color, and about 3/4 inch long when full grown. With the advent of warm weather in the spring, the larvae transform within their cocoons to brownish pupae about 1/2 inch long. They remain in this state for three to four weeks before they emerge as adult moths.

The emergence of first brood moths extends over a period of three to five weeks beginning shortly after petal fall and reaching a peak three to four weeks later. Some of the moths from buildings and packing houses may emerge earlier or later than those overwintering in the orchard. Oviposition begins three to seven days after emergence depending on the temperature.

The female deposits her flat, disc-shaped, scale-like eggs singly on the leaves and surface of the fruit. The eggs are smaller than a pin head, are whitish in color and transparent at first. After several days a reddish ring appears followed later, just before hatching, by a black spot which is the head of the developing embryo.

The time required for the eggs to hatch depends somewhat on temperature but it averages about a week. Newly hatched caterpillars are about 1/16 inch

in length. The larvae enter the fruit either through the calyx or the cheek of the fruit. They prefer to enter through secluded areas, such as where apples touch or under leaves, and rough spots on the apple but can enter on perfectly smooth surfaces. Entries become evident by a small pile of frass at the opening in the fruit. A few weak larvae or those poisoned by insecticides may enter the fruit, but die shortly thereafter causing stings.

The time spent by the larvae in the fruit varies considerably, but averages about 30 days for the first brood and three weeks for the second. When nearly full grown the larvae burrow to the surface and keep the opening plugged with excrement until they are ready to leave the fruit. The full grown larva is about 3/4 inch in length and is pinkish white in color with the head dark brown and the thoracic and anal shields lighter brown.

Most of the first brood larvae leave the fruit before it falls and crawl down the branches until they find a place to spin their cocoons. The greater part of the first brood larvae pupate and develop into second brood adults in about 10 days (early August). A few late first brood larvae and most second brood larvae hibernate until the following spring. Generally speaking, there are two broods of codling moth produced in the Northeast each year. Exceptions are that the northern areas may have only a partial second brood some years and a third brood may be produced further south.

Damage

Formerly the codling moth was a very serious insect pest of apples, infesting up to 95% of the fruit if uncontrolled. However, due to the development of new more effective insecticidal chemicals, it is now so well controlled in commercially sprayed apple orchards that the overall damage it causes to the apple crop must be considered to be light. On the other hand, populations in abandoned or poorly sprayed orchards and in wild trees continue unabated, thus emphasizing the fact that the codling moth is still a potential threat to the industry if not properly controlled.

The codling moth larva enters the apple from the side or blossom end and tunnels through the apple to the core causing large injured areas that are filled with its excrement (frass). The fruit often drops and is inedible.

European Red Mite

Description

The European red mite is a tiny reddish, eight-legged spider mite, almost too small to be seen without magnification. The presence of mites is more easily diagnosed by the bronzed appearance of the leaves. The eggs are very small, spherical and reddish in color. When numerous they may resemble a coating of red brick dust on the bark or in the calyx of the fruit.

Life Cycle

The European red mite passes the winter in the egg stage on the surface of small branches of the tree, in crevices and crotches of fruit spurs and on the smooth area under the rough bark scales on the larger scaffold limbs and trunk. The eggs are very small, spherical, and reddish in color. When numerous they may resemble a coating of red brick dust. Usually they begin to hatch when the blossom buds are in the late tight cluster or early pink stage. Hatching is complete by petal fall. The newly hatched mites crawl to the leaves and begin to feed largely on the underside.

The period from the date of hatch until the first adults appear is about two weeks depending on the temperature. In mid-summer this interval may be reduced to 10 days. Usually injury can be first observed on the leaves growing on the fruit spurs near the center of the tree. This is particularly true when pre-bloom applicatons of ovicides for control have been made and the coverage on the eggs deposited under the loose bark on the scaffold limbs and trunk is inadequate. Seven or more generations may follow in rapid succession throughout the summer and early fall.

Damage

Low to moderate infestations of red mite cause slight discoloration of the foliage and reduced tree vigor. Heavy infestations result in bronzing

of the leaves, leaf drop, small fruit with poor color and sometimes premature fruit drop. Severe infestations early in the season have been shown to reduce the bloom the following year. Although infestations building up in late August have not been proven to cause serious damage, excessive and early harvest drop has resulted in some cases. Also, when mite infestations become heavy in late August and September the females deposit large numbers of eggs in the calyx and stem ends of the apple. In heavy crop years such fruit is often rejected by the processors.

Normal Mite Injury

Certain apple varieties such as Red Delicious, Baldwin, Yellow Transparent, Golden Delicious and Early McIntosh are more seriously injured than others. Pear, plums, prunes and grapes may also be attacked and injured by the European red mite.

Grape Berry Moth

Description

The adult moth is grayish or grayish-purple with a wing spread of about 1/2 inch. There are lighter-colored serpentine markings toward the ends of the forewings.

The full grown larva is 1/3 to 1/2 inch long, greenish gray with a brown head.

Life Cycle

This insect overwinters in grayish silken cocoons almost always folded in fallen grape leaves under the vines. Sometimes these cocoons are attached to loose bark scales on the trunks of the vine or in rubbish on the ground.

In late spring or early summer at about bloom time or slightly later moths emerge from the cocoons. The circular, flattened cream colored eggs are deposited singly, at dusk on the fruit stems, flower clusters, or newly formed grape berries. The tiny worms that hatch from these eggs spin a fine silken thread wherever they go thus webbing together several berries or an entire fruit cluster. These larvae at first feed on the buds, blossoms and berries. Later the first brood larvae enter the fruit that are about the size of a pea or larger. On becoming full grown each individual cuts out and folds over a little flap of a leaf forming a small envelope within which it pupates.

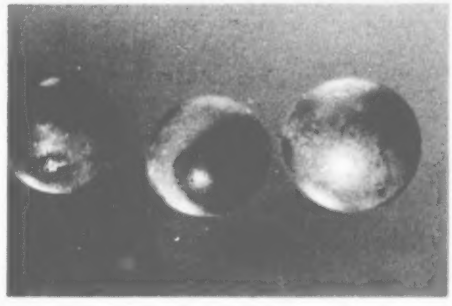
The second generation adults emerge during late July and/or early August depending on latitude and deposit their eggs as did those of the first generation.

The time required for developing from egg to full grown larvae averages about 5 weeks. After reaching this stage they again go to the leaves where they make an envelope in which to spin their cocoons and pupate. They remain in this stage until the following spring. Thus, there are two generations of this insect per year in the Northeast.

Damage

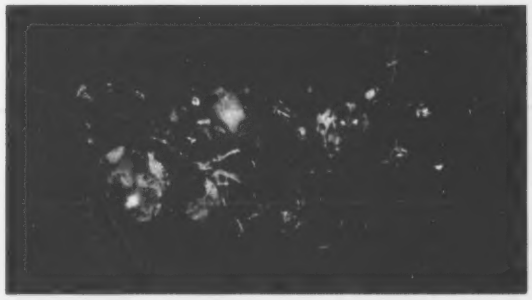
All varieties of grapes grown in the Northeast are frequently damaged by the grape berry moth when measures for its control are not taken. However, the development of new insecticides that are effective against the adult moths as well as against the larvae plus improvements in pesticide application equipment have made it possible for growers to control this pest without suffering the heavy losses it caused 15 or 20 years ago.

The first brood larvae at first feed on the buds, blossoms and berries. Later they enter the fruit that are about the size of a pea or larger. Larval entrance into the fruit causes red discolorations and sometimes causes the fruit to split. Each worm from this generation usually destroys a number of grapes.



Grapes Attacked by First Brood

The second brood of larvae hatch when the berries are large, so a larva might find enough food in a single grape to complete its development. However, it frequently migrates from one grape to another particularly when they are touching until several berries are destroyed. These berries and even the entire cluster may become webbed by the silken thread spun by the migrating worms. Not only are such clusters unsightly, but many berries or even the entire cluster may be destroyed.

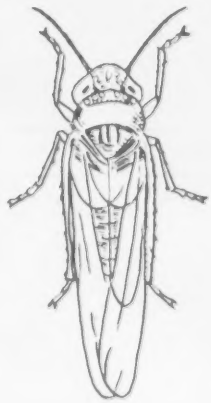


Grape Cluster at Harvest
Destroyed by Second Brood

Leafhoppers

Description

There are three leafhoppers that at various times become major pests of fruit crops in New York State. They are the grape leaf hopper, the potato leaf hopper and the white apple leaf hopper. Nymphs and adults of all three species are small, active, and with wings ridged over the body, like a tent, so that they are roughly triangular in shape. Adults are 1/8 inch or less in length. The nymphs of the grape and white apple leafhopper are a paler green or whitish color than potato leafhopper nymphs. Both nymphs and adults of the potato can be differentiated from the others because they are very wary and evasive and tend to run sideways rather than straight ahead. The grape leaf hopper adult has red markings on the wings.



Potato Leafhopper

Life Cycle

-- The grape leafhopper overwinters as an adult in protected areas, usually under leaves and in trash in or near vineyards. In early spring these adults become active and feed on a variety of plants. Migration to vineyards begins when the basal grape leaves and new shoots are well expanded. The adults feed by sucking the plant juices from the underside of the leaves. After feeding from a few days to two or three weeks the females begin oviposition by inserting eggs into the leaf tissue. The eggs hatch into pale-green or whitish green nymphs which feed almost entirely on the underside of the leaves. They become full grown in three to five weeks depending largely on the temperature. There are usually two generations per season in New York but early frosts can cause a reduction in the second generation.

-- The potato leafhopper does not overwinter in New York State. It passes the winter in all stages and breeds continuously in the southern part of the United States particularly in those states bordering the Gulf of Mexico as well as in Mexico itself. Early in the spring the adults begin to migrate northward. After several generations enroute numbers of adults appear in New York and begin to feed on beans and alfalfa as soon as they come up in June. In years when the flight is heavy large numbers soon migrate to apple, grapes, potato, alfalfa, etc. The eggs require about 10 days to hatch and the nymphs become full grown in about two weeks. After two or three or possibly four generations the potato leafhoppers are killed by frost and cold weather and disappear until the northward migration takes place the next spring.

-- The white apple leafhopper passes the winter as an egg inserted into the bark of young twigs on the apple tree. In late May the eggs hatch into tiny white or very light green nymphs which immediately begin feeding by sucking juices from the underside of the leaves. These individuals mature in late June or early July and deposit eggs for the second brood. There are two generations per year in New York State, the second reaching maturity in late August or early September.

Damage

-- The grape leafhopper is mainly a problem on grapes, but occasionally may attack Virginia creeper, apple and some other plants. It is a problem with grapes year after year.

Grape leafhopper feeding causes the leaves to become speckled with white spots that later turn brown, producing a condition called "hopper burn". This injury prevents normal vine growth and interferes with the proper ripening of the fruit. Both quantity and quality of the fruit are substantially lowered.

-- The potato leafhopper differs from the other two discussed here in that they oviposit in and feed on the petioles and main ribs on the underside of the leaves. This feeding habit causes angular chlorotic spots to develop in those areas of the leaf blade normally serviced by the injured veins. Severely injured leaves tend to become distorted and curled. It is also important to note that this species prefers and almost exclusively feeds on young succulent tissue as compared to the other two species which feed on leaves of all ages. For this reason they leave mature apple trees when the terminal bud has been set. However, on very young apple trees and on grapes they continue to feed on the young succulent leaves throughout the season. Young fruit trees, particularly apple, recently set or in the nursery can be severely injured and the terminals stunted even by moderate infestations of this insect.

-- The white apple leafhopper is the most troublesome species of leafhoppers attacking bearing apples in New York. It also causes severe injury to young newly set or non-bearing trees. The feeding on the underside of the leaves causes a whitish stippling on the upper surface. In severe cases these spots coalesce causing the leaves to become blanched until little green coloring matter is left. Such leaves become practically non-functional as far as photosynthesis is concerned and may fall prematurely.

In addition to injuring the leaves, the second brood of hoppers may speckle the fruit with excrement rendering it unsightly and lowering its market value. This is especially true of Rhode Island Greenings and other light colored varieties.

Oriental Fruit Moth

Description

The adult moth is gray with chocolate brown markings on the wing. It resembles the codling moth but is only about 1/4 inch long with a wingspread of about 1/2 inch. As with the codling moth the wings are held tentlike over the body.

The larvae when full grown are pinkish white, 1/2 inch long and resemble codling motn larvae.

Life Cycle

This pest overwinters as full grown larva about 1/2 inch long and very similar to the codling moth in cocoons in crevices on the trees or in debris under or near the trees. Pupation takes place in the spring and the first adult moths appear shortly after bloom and begin to deposit their eggs on the foliage. The moths emerge over an extended period and there are two and often three full broods per year in the Northeast.

Damage

The oriental fruit moth has become a general pest of peaches since its first appearance in the Northeast in 1926. When first introduced, the pest caused heavy losses which threatened the peach industry. It has also become a minor to moderate pest on quince, apple, pear, apricot, plum and several other fruits. In recent years the pest has become less severe possibly due to the activity of predators and parasites as well as to the development of more effective insecticides for its control.

Oriental Fruit Moth Damage

The larvae of the first brood attack the tips of growing shoots, entering near the tips

and burrowing downward for a distance of several inches. Twigs attacked in this manner wilt, die and turn brown as shown in the illustration. These injured terminals offer conspicuous evidence of this insect's presence and activity. The larvae of the second brood attack the fruit as well as the stems. The small larvae frequently enter the fruit at the point of attachment of the stem leaving little evidence of their presence. Entrances on the cheek of the fruit cause excessive gumosis at the point of entry rendering the fruit unsightly and unmarketable. Larval feeding within the fruit causes breakdown of the tissue and increases its susceptibility to rot organisms. The third generation feed almost exclusively on the fruit.

Although this insect is primarily a pest of peaches and to a lesser degree to other stone fruits, it also attacks apple and pear to a minor degree. On these later two fruits the injury to the terminals is similar to that occurring on peach. However, the injury to the fruit is similar to and may be confused with that of the codling moth or the lesser apple worm.

Plum Curculio

Description

The curculio grub is a grayish-white, legless grub with a curved body and small brown head. It is about 1/3 inch long when full grown.

The adult plum curculio is a dark brown snout beetle, about 1/4 inch long, with grayish or whitish patches on its back and four humps on its wing covers. A strongly curved snout extends about 1/3 the length of its body forward and downward from its head.

Life Cycle

The plum curculio passes the winter as an adult beetle, hibernating in and around orchards under fallen leaves, in piles of stones or any other debris that offers shelter. The beetles emerge and become active about the

time peaches and apples bloom in the spring. The specific time of emergence is largely controlled by temperature. Usually three or four seasonally hot days are required to stimulate activity. By the same token unseasonably cold weather over a prolonged period will send them back to warmer quarters and exterd the emergence period.

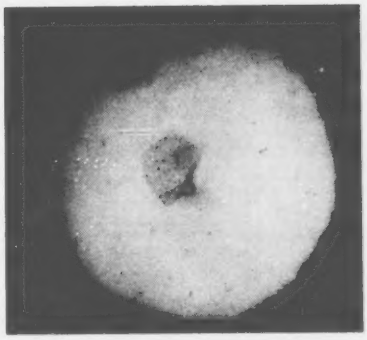
The emerged adults at first feed lightly on developing buds, foliage and newly set fruit. They then mate and the female soon begins oviposition. In this operation she first eats a small round hole in the surface of the fruit. Then turning around she deposits a small shiny white egg in the hole, and finally cuts a crescent shaped slit beneath the egg with her mouth parts leaving the egg in a flap of the fruit that will gradually die. Although as many as 500 eggs have been laid by a single female the average is estimated to be less than 100.

The young grubs hatch two to 10 days later and bore to the center of the fruit; feeding on the seeds in the case of apples and on the pits in the case of stone fruit. After becoming full grown the grub leaves the apple to work its way into the ground for an inch or two where it prepares a small cavity in which it pupates about two weeks later. About one month after the larva enters the ground about mid to late July it changes into the adult beetle and emerges to appear in the orchard as the summer generation. These adults fly to apple, peaches or other stone fruits to feed on the fruit by eating out small round holes in the skin. By inserting their curved snouts through these small holes they are able to eat out a fair sized cavity in the flesh below. From late August until late fall the adults seek out overwintering quarters where they remain until the next spring.

Damage

The plum curculio causes fruit losses in several ways. Grubs that are successful in developing in the apple and early infested peaches cause the fruit to fall at about the time of the June drop. Oviposition sites on apples that remain on the tree grow into large crescent shaped scars that lower the quality of the fruit. The illustration shows the scar. A number

of oviposition sites on any single fruit of the susceptible fruits cause them to become deformed and unmarketable. The cutting of the female during oviposition causes gumosis and deformation of peaches and plums rendering them unsightly and useless. Although infested cherries remain on the tree until ripe, processors reject this infested fruit and it is not generally acceptable to the fresh fruit customer.



Oviposition Scar

Losses from the late summer feeding of the newly emerged adults is not as great as that suffered by the ovipositon punctures and the grub feeding, but can at times significantly reduce the quality of the fruit. This injury must be considered when evaluating the total losses caused by this pest.

Raspberry Fruitworm

Description

The full grown larvae is about 1/4 inch in length, yellowish white in color, and sparsely covered with transverse rows of stiff, light brown hairs.

The beetle is about 1/7 of an inch long, light brown in color and slightly hairy.

Life Cycle

The raspberry fruitworm overwinters in a pupal cell in the ground. Adult beetles emerge in the spring. At first the beetles deposit their tiny, whitish oval eggs on the small green berries, blossom clusters, blossom stems and leaf petioles, usually so well hidden in the plant leaves that it is difficult to detect them. Later the eggs are laid only on the green berries. Upon hatching, the young grubs enter the blossom buds or young fruits where they feed largely on the fleshy receptacle.

When fully grown the larve leave the fruit and fall to the ground where just below the surface they construct earthen cells in which to pupate. In some years at least some of the grubs pupate and reach the adult stage before the advent of winter, but remain in the pupal cells until the following spring. The rest complete the development from pupae to adult in the spring. In May all beetles emerge to begin the cycle all over again. There is one generation per year.

Damage

The raspberry fruitworm, or American raspberry beetle as it is sometimes called, is widely distributed throughout the northern United States and Canada. Although it may attack black and purple raspberries, it is most injurious to red raspberries, particularly to early varieties.

The adult beetles appear on the raspberry plants in May as the new foliage is unfolding and feed on the buds and tender leaves, later attacking the blossoms themselves. If the infestation is heavy the leaves may become riddled with holes and take on a typical ragged appearance. Occasionally the blossom buds are so badly injured that much of the crop is destroyed before bloom. After the young grubs enter the blossom buds or young fruit, some of the infested fruits dry up before ripening, others decay and many others at picking time contain a larva lying between the berry and receptacle. Many of these larvae are gathered with the berries and are overlooked until the fruit is served.

Raspberry Fruitworm Larva Showing Injury to Ripe Fruit

Raspberry Fruitworm Adult Showing Bud Feeding Injury

Spittle Bug

Description

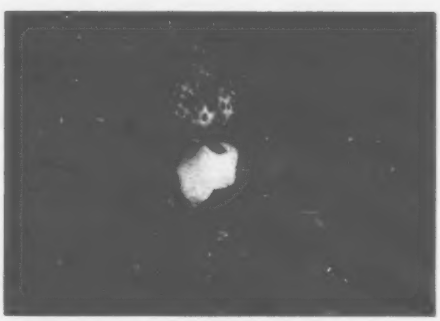
The newly hatched nymphs are bright yellow. Their presence can readily be detected by the frothy mass which they produce and with which they cover their bodies. When the nymphs become full grown, the froth dries up and the adults emerge. The adult is about 1/4 of an inch long; dull brown or mottled gray in color. (See picture, page 130).

Life Cycle

Spittle bugs overwinter in the egg stage. In the fall eggs are deposited in masses of two to 20 in a row, attached to stems and leaves of strawberry and other plants. Eggs hatch early in the spring, usually April or May. The nymphs begin feeding on the tender leaves and buds as they emerge from the crown of the plants. After five to eight weeks in the frothy mass with which they cover themselves the adults emerge, mate and, in the fall, lay eggs.

Damage

On strawberry the nymphs suck plant juices from the tender leaves and fruit which weakens the plant and stunts the berries. Nymphs often attack the flower bud clusters, leaf stems and young growth in the crowns, further stunting growth and reducing yields. The spittle which they produce is a nuisance to pickers who dislike coming in contact with this frothy mass while picking the berries.



Frothy Mass with Spittle Bug Nymph Inside

Strawberry Weevil

Description

The larval form of the strawberry weevil is a small, strongly curved, legless grub. It is white or yellowish in color. The adult is a small snout beetle, reddish brown to black and is only about 1/10 inch long. Its snout is about half as long as its body and it has two black spots on its back.

Life Cycle

The adult hibernates in the debris and duff of hedge rows and woodland adjoining strawberry plants and there is evidence that some of the beetles also pass the winter under the mulch in the strawberry beds themselves. The adults appear on the strawberry plants as soon as the blossom buds emerge from the crowns in the spring. Eggs are deposited singly in an unopened bud. The egg hatches in about a week. This grub at first feeds almost entirely on pollen within the bud, but later may attack other parts of the interior of the same bud. When full grown the grub pupates within the bud which by then has fallen to the ground. The beetle which emerges feeds for a short time on the pollen of other flowers and then goes into hibernation in midsummer where it remains until the following spring.

Damage

Throughout the eastern United States the strawberry weevil is one of the most serious insect pests affecting the strawberry. In severe infestations, losses of 40% to 50% of the berries have been recorded. Because of the type of injury this pest inflicts on a strawberry crop many growers suffer significant losses annually without recognizing the cause or in many cases without even realizing that a loss has occurred.

After depositing the egg in the bud the adult female cuts the stem supporting the bud almost through, causing the bud to hang down, still attached by the uncut portion of the stem. This cutting prevents further bud development, and loss of fruit results.

Blossom Buds Cut by Strawberry Weevil

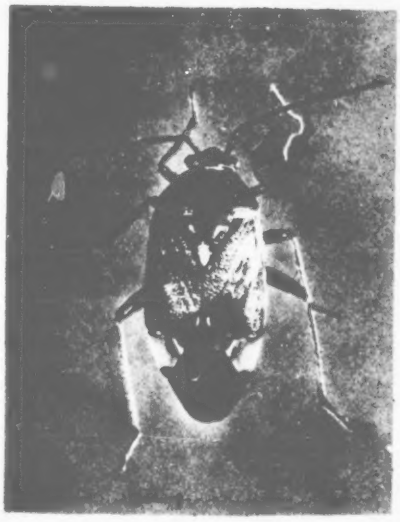
Whether or not a strawberry planting has a weevil problem can be determined in three ways: (1) Presence of the adult weevil when the plants begin development in the spring. (2) Cut buds hanging from the pedicels between the time the buds begin to separate and bloom. (3) By the presence of cluster of fruitless, budless pedicels after bloom. Because of the nature of the biology of this insect and the type of injury it causes, growers really have to look carefully to determine whether or not it is a problem in their own plantings.

Tarnished Plant Bug

Description

The adults are flat true bugs about 1/4 inch long, brownish, with the head projecting out in front and mottled with white, yellow, reddish brown and black. The insect has a brassy or tarnished appearance overall.

The nymphs are very active and resemble the adult in general appearance.



Life Cycle

The adult tarnished plant bug overwinters as an adult in trash, in hedgerows, woodlots and other areas offering protection. In the early spring it appears on numerous plant hosts where the adults begin feeding immediately on the green tissue, leaves, succulent stems and buds. After

feeding several days, eggs are inserted in the stems of herbaceous plants as well as in the soft tissue of deciduous trees including buds, fruit stems and terminals. In several days the eggs hatch into nymphs. These nymphs pass through several instars or stages gradually changing into the adult. There are several generations per year depending on the latitude.

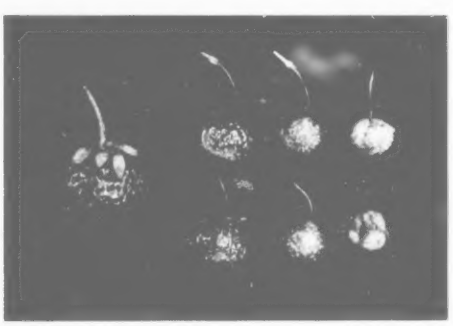
Damage

The tarnished plant bug attacks and at one time or another causes significant injury to just about all fruit crops grown in northeastern United States. It is considered a major pest on apples, pears, peaches, brambles and strawberries. This insect is a true bug and feeds by sucking the plant juices from leaves, succulent twigs and, more important, from the fruit. In feeding it injects a small amount of salivary juice into the plant tissue. Particularly on fruits this material affects cell development by restricing or preventing further growth of the tissue, causing the fruit to become deformed.

"Dimple" on Apples

"Catfacing" on Peaches

On apples and pears during the prebloom period it often feeds on the fruit buds. Extensive feeding in this manner causes the buds to "bleed" extensively often resulting in their death (blasting). Later on during bloom and the post-bloom period a single feeding puncture prevents further development of nearby cells resulting in a deep v-shaped depression in the mature fruit. Later feeding punctures produce similar injury, but not so deep as those caused by the early feeding. Several punctures per fruit cause it to become



Strawberry Injury

extremely misshapen. In any case the value of the fruit is greatly reduced and its uses limited to juice.

Plant bug injury to peach causes cells in the vicinity of the wound to die, producing a symptom known as catfacing. On brambles and strawberries early feeding on the fruit causes the berries to stop growing and to remain small, hard and to turn dark in color. Later feeding, or light feeding causes the berries to become deformed on one side or knobbed at the tip resulting in low quality, seedy unmarketable fruit.

Summary - Some Insect Pests of Tree Fruits, Vine and Small Fruit

Pest	Type of Injury	Plant Attacked	Plant Parts Attacked	Infectual or Damaging Stage	Pest Recognition	Injury Diagnosis	Control Measures
Aphids Grain Rosy Green	Suck plant juices from leaves and buds	Apple Pear	Terminal buds, leaves & fruit Terminal buds and leaves	Nymphs Adults	Rosy - bluish green Green and Grain-green plant lice	Rosy aphids cause dwarfing of fruit. All feed on buds and terminals. Green aphids produce honey dew on which sooty mold fungus grows.	Chemical: Apply aphicide prebloom and as needed. In late season predators and parasites may control population of green aphids.
Apple Maggot	Oviposition (egg laying) scar and burrowing	Apple Plum Prune	Fruit	Oviposition and Punctures by adult, larvae tunneling in fruit	Adult is 2 winged fly. Larva is small white maggot in fruit.	Shallow dimples on fruit surface caused by oviposition. Brown tunnels in fruit from burrowing larvae.	Chemical: Applyinsecticide 5-7 days after first flies emerge in early July. 1-3 additional sprays 14-21 days apart depending on potential infestation.
Codling Moth	Burrows through fruit	Apple Pear Crabapple Walnut Can damage peach, almond and cherry.	Fruit seeds	Larvae	Pinkish-white caterpillar-like worms, head dark brown	Apples with holes in flesh of fruit. Burrows running to core; seeds more or less damaged. Masses of dark castings protruding from holes	Chemical: Spray 17-21 days after petal fall. 1-2 additional sprays 14-21 days apart, or as trap flights peak.
European Red Mite	Feeds on leaf surface. Eggs in calyx of apple	Apple Pear Plums Prunes	Leaves	Nymphs Adults Eggs	Very small reddish 8-legged spider mites	Mites on leaves. Eventually bronzing of foliage.	Chemical: Oil at 1/2 inch green. Also miticide at pink and in summer if needed.
Grape Berry Moth	Feeding on grape berries	Grapes	Fruit	Larvae	Adult is a moth. Full grown larva is greenish gray with a brown head 1/3-1/2 inch long.	Feeding on berries and webbing of clusters by larvae.	Chemical: Apply insecticide at first and 2nd post bloom spray and again in late July or early August.

Summary (Cont'd.)

Pest	Type of Injury	Plant Attacked	Plant Parts Attacked	Infectual or Damaging Stage	Pest Recognition	Injury Diagnosis	Control Measures
Leaf Hoppers Grape Potato White Apple	Sucking juices from leaves Damages buds, may deform fruit	Grape - mainly grapes Potato - grapes, apples potatoes, many other White apple-primarily apples	Leaves Buds Fruit	Nymphs Adults	Leafhopper, small active insect 1/8 inch or less Wings folded tent-like over body.	Grape - white spotting later causing "hopperburn" Potato - pale spots between veins, leaves distorted White apple - causes leaf drop, excrement on fruit	Chemical: Apply insecticide soon after bloom and again in mid-summer if needed.
Oriental Fruit Moth	Bores in twigs and fruit	Peaches Apple	Twigs and fruit	Larvae	Adult is a moth. Larvae pinkish-white 1/2 inch long	Infested twigs wilt & die. Larvae in fruit cause severe bleeding of sap called gumosis.	Chemical: Apply insecticide soon after bloom and again in late July or early August.
Plum Curculio	Oviposition scars, tunneling	Apple Cherry Pear Peach Plum Prune	Fruit	Larva Adult	Larva is a small white grub. Adult is a snout beetle (weevil).	Crescent shaped oviposition scars by adult. Tunneling by larvae causes fruit to drop.	Chemical: 1-3 applications at 10 to 14 day intervals starting at petal fall.
Raspberry Fruitworm	Feeding on base of fruit and on fruit	Raspberry	Leaves by adults. Fruit by larvae	Larva	Small brown beetle Yellowish larva	Larvae feed on berries mostly on receptacle. Adults eat irregular holes in leaves and buds.	Chemical: Apply insecticide just as buds open and again just before bloom.
Spittle bug	Sucks plant juices	Strawberry and other plants	Leaves and fruit.	Nymphs Adults	True bug	Frothy spittle masses on leaves and fruit. Bright yellow nymph inside.	Chemical: Apply insecticide when insects appear before bloom and again before harvest.
Strawberry Weevil	Cuts blossom stems	Strawberry	Blossoms	Adults	Snout beetle Larva tiny white grubs	Adult lays eggs in blossom then girdles blossom stem.	Chemical: Apply insecticide as soon as blossom buds emerge in spring and again 10 days later.
Tarnished Plant Bug	Sucks juice from buds, leaves and fruit	Apple Pear Peach Prunes Cherry Strawberry Raspberry Many Others	Buds Leaves Fruit	Adults Nymphs	True bug Light to dark brown with markings	Fruit - Deep dimples or cat facing on tree fruits - nubbins on brambles and strawberries. Also sap oozing from injured buds	Chemical: Apply insecticide before bloom and as needed thereafter.

Apple Scab

Symptoms

Scab lesions of leaves and fruit

Apple scab occurs on the leaves, shoots, blossoms and fruit. Lesions first appear as velvety brown to olive spots which later turn black. Diseased leaves are often distorted and may drop prematurely. Fruit infections resemble leaf infections when young, but with age become brown and corky. Fruit infected early may become misshapen and cracked as it develops. Lesions usually appear around the blossom end of the fruit when the infections occur early and elsewhere on the fruit surface later in the season. Late summer fruit infections do not appear before harvest but develop during storage as "pin point" scab.

Disease Cycle

The fungus overwinters on the fallen apple leaves on the orchard floor. Tiny, black, pimple-like fruiting bodies form which when wetted discharge airborne spores. Primary spores are discharged from early April until mid June with the peak usually occurring around bloom. Periods of wetting are necessary for spore discharge and for infection to occur. The primary lesions give rise to secondary spores, whose lesions, in turn, produce more secondary spores. Secondary cycles of infection continue throughout the season during periods of wetting.

Damage

The major loss in commercial orchards where spray programs may have slipped a bit is the loss of fruit quality as a result of the unsightly

(although generally superficial) fruit lesions. However, in unsprayed orchards a high proportion of the fruit may be too cracked and misshapen to be marketable and considerable early fruit drop may occur as the result of stem infections. In unsprayed orchards sufficient early defoliation may occur to weaken the trees, reducing the flower bud production for the following season and rendering the trees more susceptible to cold injury.

Brown Rot of Stone Fruits

Symptoms

Brown rot affects blossoms, spurs, shoots, and fruit of peaches, nectarines, apricots, cherries, and plums. Infected blossoms wilt, turn brown, and persist into the summer. Brown rot blossom blight may spread into the spur, causing a small canker often accompanied by gumming. Spur cankers may expand to girdle the branch causing the terminal shoot to wilt and die. Fruit infection results in a soft, brownish colored rot which usually becomes covered with dusty gray-buff tufts of fungus growth on the surface. Rotted fruit dry and shrivel into characteristic "mummies".

Peach Brown Rot Mummies

Disease Cycle

The brown rot fungus overwinters in the mummies, both on the ground and remaining clinging to the tree. About the time the fruit buds open in the spring, small, mushroom like fruiting structures develop from the mummies on the ground. These fruiting structures produce airborne spores that infect open blossoms under warm, humid conditions. These fruiting structures disintegrate shortly after

bloom and do not contribute to later fruit infections. The spores produced by mummies hanging in the tree, however, are a different kind and contribute to infections throughout the season. Uninjured green fruit are relatively resistant to infection but gradually become susceptible as they ripen. Wounds in the fruit, such as caused by insects, hail, or wind whipping, are highly susceptible to infection.

Brown Rot on Peach Fruit

Damage

Although brown rot blossom blight can cause direct losses of fruit production through the killing of blossoms and fruiting spurs, its main effect is indirectly through the build-up of inoculum for later fruit infections. Brown rot infected fruit are totally unmarketable and must be quickly sorted from the healthy fruit soon after harvest to prevent the rapid spread of the disease in storage and on the market shelf.

Collar Rot of Apples

Symptoms

Collar rot refers to a canker which occurs at or just below the soil line at the base of an apple trunk. Infected bark becomes brown and is often slimy when wet. The cankers often extend down 8-10 inches into the roots and may extend up the trunk above the bud union. When the canker girdles the roots or lower trunk, top symptoms typical of girdling appear, namely yellow-reddish leaves and poor terminal growth. Severely infected trees eventually die.

Disease Cycle

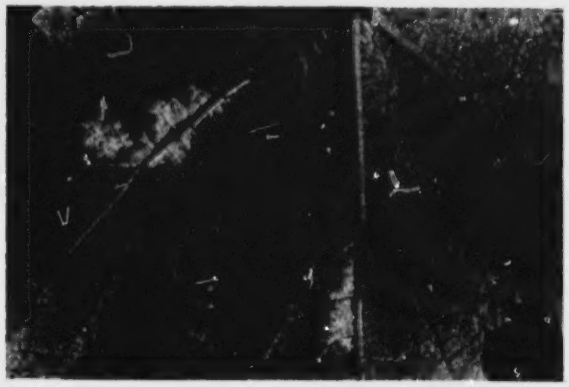
The fungus survives in the soil for several years as thick walled spores resistant to drought and chemical treatment. During favorable conditions (cool, damp periods in the spring and fall) these spores germinate to release tiny swarm spores that swim through the films of moisture between soil particles and infect bark at the bases of the major roots.

Damage

Young apple trees on MM104 or MM106 rootstocks are particularly susceptible. Girdled trees are usually killed.

Downy Mildew of Grapes

Symptoms



Downy Mildew on Grape Leaf Underside

Downy mildew may appear on any succulent part of the vine, leaves, shoots, flowers, and immature fruit clusters. On infected leaves a pale yellow indefinite spot appears on the upper side of the leaf, while on the underside of the spot the white, downy growth of the fungus appears. This spot later enlarges and turns brown with the downy fungus growth in a narrow ring around the margin. Young shoots infected by downy mildew are shorter and thicker than normal and eventually become covered by the thick, downy aerial growth. Flowers and young fruit may become overgrown by the downy fruiting masses, and often the entire cluster or a portion of it dies. Infected berries tend to shell off the vine.

Disease Cycle

The downy mildew fungus overwinters in thick-walled spores embedded in the decaying leaves on the ground. These germinate to release swarm spores which are splashed to the lower leaves during rainy periods. Infection takes place only through the open stomata on the undersides of the leaves. Secondary spores are wind disseminated and germinate by releasing swarm spores in water droplets on the leaves.

Damage

Losses are more likely to result from the effect on the vine than on direct losses of fruit, although early infections may entirely kill young fruit clusters. Extensive defoliation and killing of leaf tissue prevents the fruit from maturing properly and renders the canes more susceptible to cold injury.

Fire Blight

Symptoms

Blossoms and leaves affected by fire blight wilt and collapse. Pear leaves turn black and apple leaves turn brown. The infection progresses down the spur and down the shoot killing bark tissue as it goes, leaving the inner bark water-soaked and reddish brown. A milky ooze often appears on the surface of infected bark. The cankered bark is somewhat darker than the surrounding healthy bark, and as it dries, it becomes somewhat depressed. Entire branches may be killed by fire blight, giving trees the appearance of having been scorched by fire.

Leaves and Twigs killed by Fire Blight

Disease Cycle

The fire blight bacterium overwinters in the live bark at the margin of a holdover canker. With the warm rains of early spring, bacteria ooze to the surface of the canker. The coze is disseminated by splashing rain and by insects to open blossoms. Pollinating insects carry the bacteria from the first infected blossoms to other blossoms. The infection progresses from the blossoms down through the spur to the branch. Succulent new shoots are inoculated by wind-driven rain and by sucking insects, notably aphids, leafhoppers, and plant bugs. Bacteria may also be unwittingly transmitted by pruning tools.

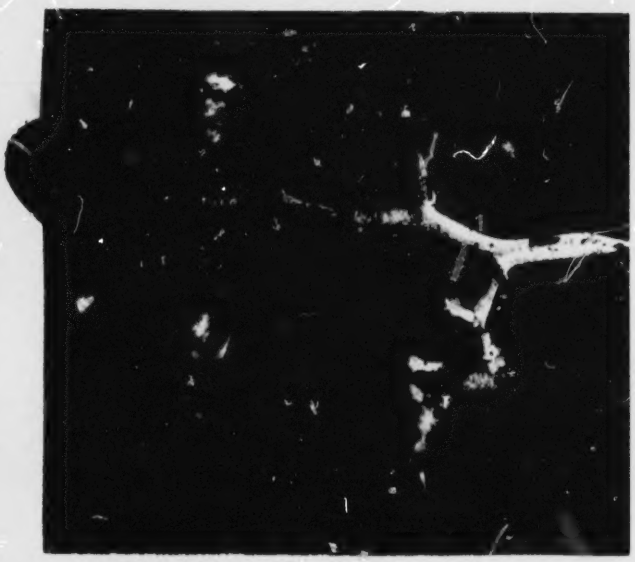
Damage

Branches or entire trees, especially young, highly vigorous ones, may be killed within a few weeks. Trees may be killed by root infection resulting from invasion through root sprouts.

Grape Powdery Mildew

Symptoms

Grape powdery mildew may be found on any new growth--leaves shoots, flowers, and fruit cluster. Without the aid of a lens it is most readily differentiated from downy mildew on the leaves. Powdery mildew generally occurs on the upper surface of the leaf while downy mildew occurs only on the lower surface. Powdery mildew is superficial while downy mildew produces a definite lesion visible from both sides of the leaf. Early powdery mildew infections of clusters may cause the flowers to wither and drop without



Powdery Mildew on Berries and Cluster Stems

setting fruit. Symptoms of fruit infection by powdery mildew vary widely depending on the severity of infection, ranging from superficial rusty spots which have corked over to misshapen, split berries which dry down like raisins. Infected areas are covered by a dusty, white fungal mass which late in the season becomes dotted with the tiny, black fruiting bodies of the fungus.

Disease Cycle

The powdery mildew fungus may overwinter in the fruiting bodies on the dead leaves on the ground or in dormant buds infected the previous season. Primary infections occur early in the spring from wind-borne spores germinating on newly expanding leaves and shoots. These infections within a few days give rise to secondary spores that are spead by air currents over wide areas. Spore production is enhanced by dry weather, and spore germination takes place under high humidity in the absence of free water on the surface of the leaf.

Damage

On American varieties powdery mildew rarely causes extensive damage. The "vinifera" and "French hybrid" varieties, however, are generally highly susceptible, and severe losses may occur from blasting of infected flowers, shelling of infected fruit, and withering of infected fruit that does not drop.

Gray Mold of Strawberries

Symptoms

Gray mold, while generally regarded as a fruit rot, usually starts the season as a blossom blight. One or more of the flowers in a cluster may be blasted with the rot often extending down the stem. As the berries enlarge, the cap will often show the infection initiated in the blossom. A cap infection almost invariably spreads to the berry. Berries may be infected any where, cap, sides, or tip. The rot is soft at first but later dries out. During humid weather the infected areas become covered with the fine, gray, fuzzy fruiting stalks and spores of the fungus.

Disease Cycle

The fungus overwinters on the decaying vegetation in the soil in the form of small black resistant structures about the size of a grain of wheat. In the spring they produce spores that are carried by air currents to the open blossoms where in turn another crop of spores is produced, spreading the disease.

Damage

The losses caused by gray mold are highly dependent on the weather. If it is dry, few infections occur so losses are negligible. However, if there are frequent light rains or heavy dews during bloom and while the fruit is maturing, most of the fruit can be rotted.

Fruit Rotting from Gray Mold

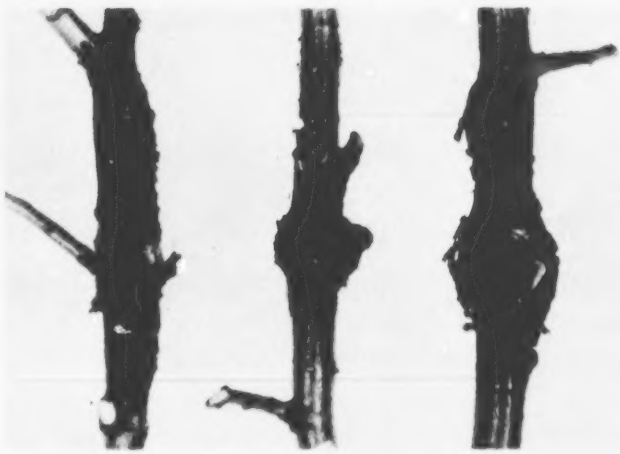
Valsa Canker

Symptoms

The first visible symptom of Valsa infection is the exudation of gum near the point of infection. The gum first has a light amber color which gradually turns to dark brown. Beneath the gum, the inner bark begins to collapse, leaving a depressed area on the surface of the bark. The fungus advances more rapidly up and down the branch than around the branch, giving the canker an elongated or elliptical shape. The bark dries out and dies but usually remains intact the first year. In succeeding years the bark becomes broken, disorganized and covered with a black fungus overgrowth. Old cankers often show "annual rings" of wound callus which mark the seasonal

advance of the fungus followed by the tree's "attempt" to heal over the wound. Along with the gum oozing from the canker, there may be frass from lesser peach tree borers which often invade the cankers.

An often over-looked symptom is the dieback of Valsa-infected twigs in the spring and early summer, usually accompanied by gumming at the base of the twig. The second year a typical canker usually develops on the main branch around the base of the dead twig.



Valsa Canker on Peach
(older cankers on right)

Disease Cycle

Valsa canker is caused by two species of fungi that cannot invade through intact, healthy bark, but require a wound or dead or dying tissue to become established before they can infect healthy tissue. The most common points of entry are: (1) winter-injured tissue, which often occurs in narrow-angled crotches, in tender twigs and buds, and in sunscalded bark; (2) pruning cuts particularly those made when the tree is dormant; (3) pruning stubs, which dry out and die back to the main branch; (4) injuries made by insects and diseases; (5) mechanical injuries to the bark and branches.

New infections usually start in the late fall or early spring when the tree is dormant but the temperatures are just high enough for fungus activity. As the temperatures rise during the late spring, the cambium of the tree becomes active and the growth of the fungus slows down. Wound callus is formed

which tends to heal over the canker. As the tree becomes dormant again in the fall, the fungus resumes activity and enlarges the canker. Growth of the fungus continues all winter whenever the temperature rises above freezing and stops again in the spring when growth of the tree resumes.

The Valsa fungi produce spores in tiny, black, pimple-like fruiting bodies which erupt through the bark. Technically, there are two kinds of fruiting bodies, each producing a different kind of spore. The spores are disseminated mainly by splashing rain, but also to some degree by wind, insects, birds, man and machines. In infested orchards viable spores can be found the year round sticking to the surface of twigs, branches and trunks.

Damage

Valsa canker is a very destructive peach disease whose losses can be measured not only in reduced yields but also in death of trees. Cankers occurring on large scaffold branches, in the main crotches, or on the trunk may enlarge to girdle and kill the portion of the tree above that point. Though considered primarily a peach disease in New York, Valsa canker can also infect apricots, plums, prunes, and sweet and sour cherries.

Verticillium Wilt

Symptoms

The symptoms of Verticillium wilt vary somewhat depending upon the crop that is infected, but they generally have in common some degree of wilting and some discoloration of the vascular tissue. On strawberries, Verticillium wilt usually occurs on scattered, individual plants. The outer leaves turn yellow or red, wilt, and die. A brownish discoloration usually develops in the vascular tissues of the crown, and streaks may run up the stems of the leaves.

On raspberries, symptoms may appear on only a few young shoots developing from a single mother plant. As the disease progresses up the stem, the older leaves turn yellow and drop off. Finally the tip of the shoot wilts, and the entire shoot withers and dies.

On stone fruits the disease often affects only one branch or one side of a tree. True wilt may not occur, but invariably there is some degree of yellowing or browning of the leaves beginning at the base of the affected branch and progressing upward. Brownish streaks or sometimes a complete brown ring appear in the sapwood. It is not easy to distinguish the wood discoloration caused by cold injury from that caused by Verticillium wilt.

Verticillium Wilt on Peach Showing Wood Discoloration

Disease Cycle

The fungus is a common inhabitant of the soil where it can persist for 2-3 years in the absence of a susceptible host plant. It can build up in the soil on many susceptible crops, including tomatoes, peppers, eggplants, strawberries, raspberries, and stone fruits. There are also many susceptible weeds, including lamb's quarters, pigweed, horse nettle, and ground cherry.

The fungus gains entrance into the plant through injuries on the roots, such as occur at planting or during cultivation. It is dispersed through the movement of infested soil.

Damage

Once infected, the plant usually dies. However, vigorously growing stone fruit trees occasionally recover.

Summary - Some Diseases of Tree Fruit, Vine and Small Fruit

Name of Pest	Type of Injury	Plant Type Attacked	Plant Parts Attacked	Infectual or Damaging Stage	Additional Favorable Conditions	Injury Diagnosis	Control Measures
Apple Scab	Deformed fruit	Apple	Leaves Fruit	Spores discharged from fruiting bodies on dead leaves on ground. Secondary spores on leaves	Intermittent rains and mild temperatures favor infection.	Dark, velvety spots on leaves Dark, scabby lesions on fruit, which may be deformed by early infection	Chemical: Spray programs begin at green tip, when first primary tissues emerge from the bud and first primary spores are discharged, continue through cover sprays.
Brown Rot of Stone Fruits	Dead blossoms Rotted fruit Occasional small cankers	Cherries Peaches Apricots Plums	Blossoms Green fruit Intact fruit	Windborne spores that have overwintered in mummified fruits	High temperature and high humidity favor infection.	Blossoms die and hang in place. Twigs blight and die back Cankers form Fruits rot and become covered with dusty spores.	Chemical: Spray programs begin during pink and bloom stages all through season as recommended. Cultural: Remove mummies from tree. Bury ground mummies by cultivation.
Collar Rot	Rot of bark at soil line	Apple	Rootstock	Motile spores swimming in soil moisture	MM104, 106 rootstocks highly susceptible	Death of bark on roots within 5 inches of the surface	Chemical: Drench trunk with Bordeaux mixture. Cultural: Avoid MM104 and MM106 rootstock. Improve soil drainage.
Downy Mildew of Grapes	Lesions on leaves Blasting of blossoms and fruit.	Grapes	Leaves Fruit bunches Cluster stalks Berry stems	Spores from overwintered fruiting bodies on dead leaves on ground. Secondarily from windborne spores	Rainy periods lasting several days favor infection.	Downy, white lesions on underside of leaf, yellow-brown spot above Blasting of blossoms and fruit	Chemical: 1-2 prebloom sprays at 10-14 day intervals. 3-4 postbloom sprays at 2-3 week intervals.
Fire Blight	Dead shoots Dead blossoms Branch cankers Rotted fruit	Apple Pear	Blossoms Shoots Fruit Branches	Bacterium overwintering in cankers, and spreading to flowers	Warm, humid weather favors development	Brown or black blossoms and spurs New shoots killed from tip, turning brown or black Brown or black spreading cankers with creamy white ooze Blackened, sunken bark	Chemical: 2-4 sprays of a bactericide during bloom. Cultural: Remove overwintering cankers. Sound cultural practices. Control sucking insects.

Summary (Cont'd.)

Name of Pest	Type of Injury	Plant Type Attacked	Plant Parts Attacked	Infectual or Damaging Stage	Additional Favorable Conditions	Injury Diagnosis	Control Measures
Grape Powdery Mildew	Retards normal ripening of the fruit. Blasting of blossoms & fruit	Grapes	Leaves Fruit bunches Cluster stalks Berry stems	Spores from overwintered fruiting bodies Secondarily, from windborne spores	High humidity without rain favors infection.	White powdery or dusty growth on the upper sides of leaves and other green parts of the fine Blasting of blossoms and fruit of highly susceptible varieties.	Chemical: Fungicide applied 7-10 days after the post-bloom spray; second spray 2-3 weeks later. Pre-bloom sprays needed on highly susceptible varieties.
Gray Mold of Strawberries	Rotting fruit	Grapes Strawberries Raspberries	Blossoms Fruit	Windborne spores	Warm rains favor infection.	Gray, powdery mold on flowers and fruit	Chemical: Fungicide sprays pre-bloom and bloom and as fruit ripens.
Valsa Canker	Dead shoots Dead branches Branch and trunk cankers	Peach Cherry Apricots Prunes	Shoots Branches Trunk	Spores oozing from old cankers during wet periods	Wet weather	Dead shoots dotted with black, pimple-like fungus fruiting bodies Rough, black, elongated cankers on branches and trunk often accompanied by brown ooze	Chemical: Protect pruning wounds with fungicide. Protect leaf scars in fall with fungicides. Cultural: Sanitation (remove cankers) Sound cultural practices.
Verticillium Wilt	Wilt	Cherry Peach Plum Raspberries Vegetables Weeds	Roots, water conducting system in wood	Resistant spores persisting in soil	Can persist in soil 2-3 years without host plant	One-sided wilt of tree canopy. Gradual decline and death of tree. Brownish discoloration of sapwood	Chemical: Soil fumigation with broad-spectrum fumigant. Cultural: Avoid planting fruit trees following tomatoes, potatoes, and other highly susceptible hosts. Sound cultural practices.

Some Weeds of Tree Fruits, Vines and Small Fruit

Some of the weeds that are problems in tree fruit, vine or small fruit culture are listed. Pictures and descripcions of the weeds can be found in Chapter VIII on the pages noted.

	Page
Bindweed (Field)	203
Chickweed (Common)	205
Crabgrass (Large)	205
Lambsquarters	210
Poison Ivy	212
Quackgrass	213
Yellow Nutsedge	217

The Summary of Weeds in Tree Fruits, Vine and Small Fruits immediately following will give you quick information about the weeds listed.

Summary - Some Weeds of Tree Fruit, Vine and Small Fruits

Name of Weed	Life Cycle	Brief Description	Environment Favoring	Other Crops Attacked	Time and Stage to Control	Conditions Favorable to Control	Time or Type of Control
Common Chickweed	Cool-season annual	Prostrate opposite broad leaves, small white flowers	Shaded, cool moist	Alfalfa, lawns	Late fall or early spring	Warm temperature	Chemical: Dormant season or selective sprays. Cultural: Hoeing or pulling
Crabgrass	Warm season annual grass	Hairy, narrow leaved grass, roots at node finger-like seedhead	Warm, wet weather	Numerous	Germination or seedling	Moisture	Chemical: Preemergence or early postemergence Cultural: Mowing or tillage
Field Bindweed	Warm-season perennial vine	Deep rooted vine, angular broad leaves, tubular blooms	Dry, warm weather	All field crops	Early before it has extensive root system	Multiple tillage to deplete food reserves	Chemical: No selective control, directed spray. Cultural: Hoeing or tillage
Lambsquarter	Warm-season annual	Angular stem, velvety leaf surface, globular fruits, broad leaved	Cool, wet weather	Most field crops	Germinating or young seedling	Warm weather	Chemical: Preemergence or early postemergence Cultural: Pulling
Poison Ivy	Woody perennial	3-leaflet vine, broad leaved	Non-cultivation	Ornamentals	Leaves fully expanded	Warm weather	Chemical: Foliar contact or translocated herbicide Cultural: Cutting
Quackgrass	Cool season perennial grass	Gray-green stems and leaves. Stems erect from wiray underground jointed rootstocks. Leaves flat, narrow, rough on upper surface. Heads or spikes flat with two rows of seeds on opposite sides of axis	High fertility and good moisture, highly resistent and adaptable	Field and horticultural crops	Preplow or preplant	Moisture and tillage	Chemical: Preplow or preplant Cultural: Deep tillage in the fall to expose rootstock, plowing, clean cultivation
Yellow nutsedge	Tuberous perennial sedge	Triangular stems 3-ranked leaves, yellowish seedhead, narrow leaved	Warm, moist soil	Most field and vegetable crops	Pre-sprout or early post-emergence	Warm temperatures	Chemical: Preplant incorporate or early post-emergence Cultural: Hoeing or mowing

VII. CHRISTMAS TREE PESTS

Special Problems

Christmas trees are a long term crop; consequently the grower must limit the total chemical control program if he is to profit when the tree is finally marketed. Much of his pest control budget will probably be expended on herbicides, with fungicides and insecticides used in a secondary manner. Drift, as always, should be prevented, but frequently is less of a problem than when treating other commodities, since the plantation is usually remote. The applicator must also remember that he is working in an area attractive to wildlife and should choose methods and materials that will cause minimum impact.

-- Weed Control. Most Christmas trees in the northeast are planted on abandoned pastures and untillable hillsides on old sod with brush mixed in. Sod affects the growth and quality of Christmas trees, particularly when they are small. It furnishes cover for pests, stresses the trees by competing for soil nutrients and moisture and is a fire hazard. Trees are marketable sooner when this competition is removed.

Young transplants in particular may suffer phytotoxic effects from herbicides that they can tolerate later. Herbicide application prior to planting will give the young tree a good start and will not subject the foliage to a spray.

However, you must take steps to prevent erosion, particularly on hillsides, when the sod that prevents soil erosion is killed. Planting across the hillside and leaving untreated strips of sod between rows is suggested. Herbicides used should not leave residues that will injure the transplants following.

If herbicides are used after the trees are planted there are two general methods, an overspray where the total area including the trees is treated, or a directed spray where the herbicide is applied to the unwanted vegetation, but not to the trees. Oversprays are generally cheaper and faster to apply but limit choice of herbicides to those the trees will tolerate. Even so there is likely to be some phytotoxicity. Directed sprays are usually more time

consuming, more expensive and one must be more aware of possible drift damage to the Christmas trees, but the chances for phytotoxicity are less since the trees are not sprayed.

-- Insect and Disease Control. Probably the greatest problem facing the commercial applicator who must treat insects or diseases on Christmas trees is the inaccessibility of most plantations. They are usually located on hilly or otherwise untillable land and access lanes within the plantation are lacking. Because the trees are usually several years old, obtaining satisfactory coverage is difficult and may require individual application with hand-held guns and hoses, or backpack sprayers or mist blowers. Frequently the economics of such applications are questionable and the grower simply cannot afford to pay the commercial applicator the money he requires to make a profit. Consequently the grower has a greater responsibility to inspect and discover insect or disease problems in their early stages so that infested trees can be destroyed and spot applications of pesticides can be made only to the infested area before the problem spreads.

Aerial application may reduce the problems of accessibility although the terrain may be rather difficult to fly. However, the need for adequate coverage may limit the pests against which aerial application can be used.

The applicator must be sure he wears protective clothing that is adequate for the pesticide used. The trees may be as tall or taller than he is and weeds may be waist high. Under these conditions, inadequate clothing can wet through quickly, exposing the applicator to the pesticide.

Application Methods and Equipment

Because of the inaccessibility of many Christmas tree plantations, hand equipment may be used even by commercial applicators. Knapsack sprayers, hand operated granule spreaders and backpack mist blowers are examples.

Boom equipment, hydraulic sprayers, large mist blowers, broadcast granule spreaders, and agricultural aircraft are also used for pest control in Christmas tree plantations. The following outline refers you to the appropriate pages in Chapter III for description of equipment.

Page

Sprayers
Boom Sprayers - Low Pressure and High Pressure. 53
High Pressure (Hydraulic) Hand Gun and Hose 59
Mist Blowers. 65
Granule Spreaders
Broadcast Applicators 67
Agricultural Aircraft. 75

Some Christmas Tree Insects

Eastern Spruce Gall Aphid

Description

Eastern spruce gall aphids produce pineapple-shaped growths 1/2 to one inch long, which are usually found near the base of the twig. In early summer, new galls are green with purple or reddish curved markings. Old galls are reddish-brown and have open cavities. Terminal buds are not destroyed until the entire twig dies.

Life Cycle

Only females of the eastern spruce gall aphid are known to occur. Immature females winter on twigs, usually near the terminal buds. In early spring, the insects begin feeding; when mature, they produce a conspicuous waxy cover under which they lay a mass of eggs. The eggs hatch in a week and the young insects start feeding at the base of the developing needles. Continued feeding induces abnormal growth at the bases of the needles until the aphids are entirely enclosed in a gall of plant tissue. Here the insects complete their development.

Galls and aphids mature in mid-summer. The gall dries and splits around the deformed needle bases and the aphids emerge. These young females shed

their skins, develop wings and fly to the needles of the same or another spruce tree. They lay eggs at the base of the new buds.

Cooley Spruce Gall Aphid

Cooley spruce gall aphids form a larger gall, one to three inches long, usually covering the entire tips of the infested new growth. Terminal buds are injured quickly. These aphids frequently migrate to Douglas-fir as an alternate host, but do not produce galls on this tree. Severe aphid feeding on Douglas-fir may cause yellowing and crooking of needles and partial needle fall, but normally, little disfiguration (real damage) to the tree results.

Life Cycle

Immature females of the Cooley spruce gall aphid winter on spruce or Douglas-fir and produce a waxy covering in the spring. The egg masses are laid under this covering which resembles a small cottony mass. These are conspicuous on the twigs. The eggs hatch and the young insects crawl to the developing buds and begin to feed at the base of the new needles, eventually forming a gall. During middle to late summer, the gall opens and the mature aphids emerge. Some females may migrate to Douglas-fir to lay their eggs. The eggs hatch and the young insects winter there. In the spring, they feed on the needles, mature and lay eggs. These hatch and develop into adults that remain on the fir or fly back to spruce to lay eggs for a new generation. The presence of Douglas-fir is not necessary, however, as the aphids can maintain themselves on spruce alone.

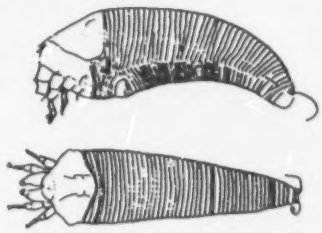
Damage (Cooley and Eastern Spruce Gall Aphid)

Galls interfere with the natural formation of twigs, causing curling, stunting, and the eventual death of new growth. Heavy infestations give the

trees a ragged appearance, destroying their beauty. Some trees have a natural resistance or immunity to these aphids, and in spite of the presence of the insects, the galls never completely develop or may not form at all.

Eriophyid Mites

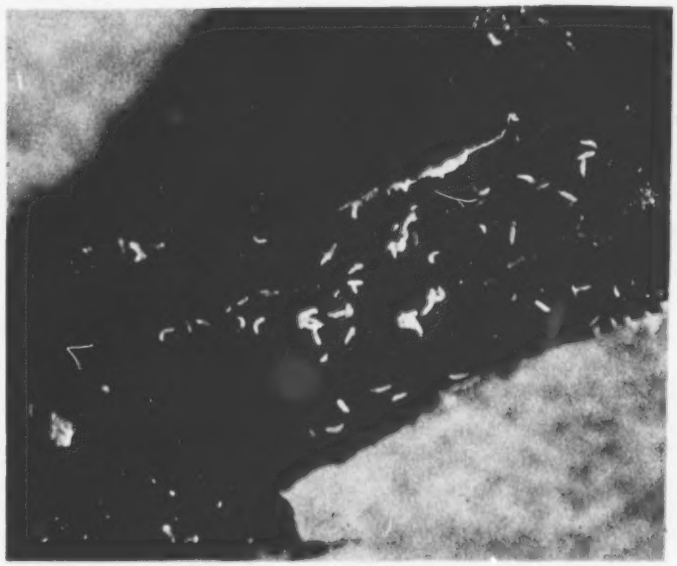
Description



Eriophyid mites are tiny, elongate, cone shaped animals that have become a major threat to Scots pine Christmas tree production. The mite itself is nearly microscopic but can be seen with a hand lens underneath the needle sheath. Nymphs resemble the adults. An infestation on Scots pine is more readily recognized by the short, sparse, discolored needles and premature needle drop resulting in a "thinned" appearance of the foliage.

Life Cycle

Three species of eriophyid mites infest Scots pine in the northeast. All three overwinter between facing surfaces at the base of the current year's needles. When the "candles" elongate in the spring the overwintering mites move to the new growth, reproduce and build up to peak populations in late summer under the needle sheaths.



Mites Under Needle Sheath in Late Summer

Damage

Eriophyid mites are recognized as a limiting factor in Scots pine Christmas tree production in the Northeast. Both nymph and adults feed on the cell contents, causing stunting and yellowing of the needles, premature needle drop

and a general thinning of the foliage. Severely infested trees retain only the current year's needles and may drop a portion of them. Since the mites are not easily seen by one not familiar with the problem, the damage is often mistakenly thought to be the result of poor site, needle cast diseases or air pollution.

Typical Eriophyid Mite Damage

European Pine Shoot Moth

Description

The adult moth has a wing expanse of about 3/4 inch. The forewings are bright, reddish orange with silvery irregular bands crossing them.

Adult European Pine Shoot Moth

The larva is dark brown with a black head. When fully developed the larva is 5/8 to 3/4 inch long.

Life Cycle

The moths appear in June and early July and lay eggs on buds, twigs, needle sheaths and occasionally on needles. The newly hatched larvae feed on the base of the needles. Later the buds are attacked, resulting in a flow of resin (pitch). At the end of summer the larvae are about 1/4 inch long.

Young Larvae at Base of Needles

The larvae overwinter in masses of pitch attached to or within buds. In the spring the larvae begin feeding again.

External feeding deforms the growing bud; internal feeding kills it. The larvae finish feeding by mid-May and pupate in a mined-out tunnel, with the moths emerging some 18 days later. There is one generation per year.

Deformed Growing Tip

Damage

The destruction of young infested buds results in deformed terminal branches that are twisted and stunted. Those terminals that die are highly visible in the spring as reddish-brown dead tips. The tree becomes stunted and bushy after repeated attacks.

Red Pine Sawfly

Description

In the larval stage both the red pine sawfly and the red-headed pine sawfly are caterpillar-like with three pairs of legs on the thorax and eight pairs on the abdomen.

When full grown the larva of the red pine sawfly is about 3/4 inch in length, and the body may be grayish-green to black on the back and greenish white on the underside. The mid-dorsal stripe is light green, bounded by a lighter stripe above and below on each side and it extends the length of the back. A blackish stripe is present at the base of the legs. The thoracic legs are also black with whitish rings. Prior to pupation, the head, usually black, may turn yellowish brown. In addition, the four longitudinal stripes become more distinctly blackish.

The adults are about 1/4 inch long and resemble small wasps.

Life Cycle

There is one generation annually. The insect spends the winter as an egg in the needles. The larvae emerge in May and usually complete their growth by June before the current year's needle growth is completed. They pupate in the litter near the base of the trees. The adults emerge during September and October.

When mature the larvae spin tough capsule-like cocoons in the forest litter in or on the ground and sometimes on the tree. The wasp-like adults emerge and lay eggs singly in slits cut in the needles of the host tree. These slits are cut by a saw-like ovipositer used to deposit the eggs, hence the common name sawflies.

Red-headed Pine Sawfly

Description

Newly hatched larvae are whitish, faintly marked and have brownish heads. After molting, the bodies become yellowish white with six rows of conspicuous black spots that extend the length of the insect, and the head turns reddish. The larvae are fully grown in 25 to 31 days and average 7/8 to one inch in length. When ready to pupate, they drop to the ground and spin tough, reddish brown capsule-shaped cocoons 5/16 to 7/16 inch long in the top soil.

The adults are small wasp-like flies that are similar in appearance to the red pine sawfly.

Life Cycle

The larva of the red pine sawfly prefers red pine but it will feed on jack, mugho and Japanese red pines. At times older larvae feed on white pine that is growing in close association with red pine.

The red-headed pine sawfly is one of the most widespread and destructive of the native species attacking pine trees. It is often abundant in northern

New York State on red pine. Pines having needles in clusters of two to three are preferred. Host plants are red, pitch, Scotch, Austrian, mugho, jack, loblolly, slash, Japanese red and Virginia pines. Occasionally Eastern white pine may be attacked.

The larvae of both species usually feed in groups and strip one branch of needles before they move on to another branch. They prefer old needles but may eat new needles later in the summer or when food is scarce. The feeding pattern varies with the species, but in most cases, severe defoliation will kill the trees.

Pine Needle Scale

Description

Adult male scales are pure white, about 1/25 of an inch long and have a single pair of wings. The males are active fliers and appear late in the summer.

The mature female scales are about 1/10 of an inch in length. They are elongate, sedentary, nearly white and possess a small orange, nipple-like structure at one end. The scale widens toward the posterior end giving it a pear-shaped appearance.

Life Cycle

The purplish-red eggs are deposited on the needles in late August and September, and the insect passes the winter in the egg stage under the female scale. In New York State the eggs hatch during mid-May or early June, depending on locality and weather conditions.

The young nymphs (called "crawlers") are lemon-yellow in color and possess well developed legs and antennae. They may hatch and remain under the

parent scale if the temperature is low. On warm days they crawl out from under the scales and migrate to young needles where they wander for a few hours. After the nymphs molt once they lose their legs and settle down on the needles to feed. Growing slowly, the insect reaches maturity by late July or early August.

Damage

Sap loss in the needles caused by the sucking actions of these insects may weaken trees and give them a pale green, sickly appearance. The foliage turns yellow and mottled and if unsprayed the needles eventually turn brown and drop. Uncontrolled infestations gradually kill branches and sometimes the entire tree.

White Pine Weevil

Description

An adult white-pine weevil is about one-fourth inch long. The insect is characterized by a distinctive tapered head with a slender protruding beak-like snout. The antennae are located at or just behind the middle of the snout; at its base the eyes are widely separated. The body is covered with tiny reddish-brown and white scales with a distinct irregular patch of greyish-white scales near the rear of each wing cover.

The larva is legless, creamy white in color, and slightly longer than the adult weevil. The head of the larva is small and light brown with distinct eye spots. Larvae are found under the bark or in the wood of a weeviled shoot.

The pupae are creamy white with brown eye spots. The abdominal tip is square. As the pupae approach maturity the beak and legs begin to turn brown and the general color of the adult is assumed. The pupae are about the same length as the adults.

Life Cycle

The white-pine weevil has one generation a year. Adult weevils hibernate in the ground litter near the base of host trees. In New York State the weevils usually become active during April -- about the time the buds on the white pine begin to swell. On leaving the litter they crawl up or fly to the vertical terminal shoot of the host tree and feed on the inner bark tissue. Egg laying may start as early as mid-April in the southern counties of the state and extend through June in the more northern counties. A single terminal shoot may contain from 20 to over 350 eggs, depending upon the number of females laying eggs. The female may visit more than one leader to deposit her eggs and any single leader may contain eggs deposited by several female weevils. Resin flows over the bark and eventually fills the chambers containing the eggs. Exposure to the air hardens the resin and acts as a sealing agent. The eggs hatch in five to 10 days.

The larvae feed at the juncture of bark and wood, destroying the cambium and inner bark tissue in their downward progress. As they mature they tunnel into the wood and pupate in the pith. Others may pupate in shallow cavities chewed out in the surface of the wood; the cavities are covered with the excelsior-like strips of wood removed in excavation. These are the chip cocoons.

Larvae in different stages of development may be found in leaders as egg laying occurs over a month's time. As a result emergence may span from June to September.

Damage

The important external symptoms of attack are confined to the leader and differ depending on the time of year observations are made.

In the spring when adults are feeding, mating, and laying eggs, glistening water-like resin droplets may be observed on the leader for a distance of several inches below the terminal buds. Oozing from the feeding punctures, the resin dries and turns whitish. The new terminal growth of attacked leaders is

darker green than normal. As the season progresses the new growth wilts and assumes the form of a shepherd's crook; it dries and turns brown. The bark of the stem below the new growth turns from green to brown as the larvae, feeding under the bark, progress downward. By mid-summer, in most localities, the needles on the killed portion have turned yellowish to brown. At this time, or shortly after, the new generation of beetles exists under the bark. They escape to the outside by chewing BB-shot sized holes through the bark. These holes, with chip cocoons under the bark, dried resin, withered stem, and browned foliage identify the injury as that of the white-pine weevil.

Variations of the typical symptoms do occur. If adult feeding on the leader in the spring is very heavy, the leader may be girdled and the terminal buds produce no new height growth.

Summary - Some Insect Pests of Christmas Trees

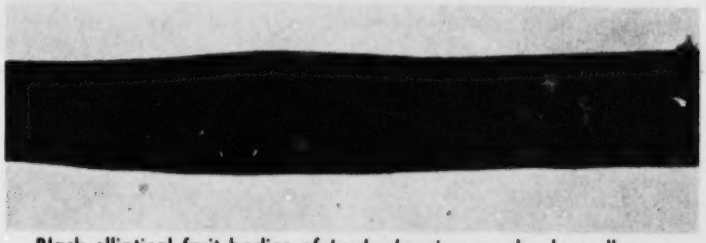
Name of Pest	Type of Feeding	Plant Type Attacked	Plant Parts Attacked	Signs of Injury	Insect Recognition	Life Stages Best Controlled by Insecticides	Control
Eriophyid Mites	Sucking	Scots Pine	Base of needles within needle sheath	Short, sparse yellowed needles that drop prematurely	Visible with hand lens as tiny cone shaped mites between needles or under needle sheaths	Nymph Adult	Chemical: Spray after new candles have elongated but before needles elongate. Inspect plantation annually in August for symptoms.
European Pine Shoot Moth	Chewing (burrowing)	Pines	In or on terminal buds	Dead or distorted buds at terminal branches	Larva dark brown with black head, about 3/4 inch long when fully grown. Moth has bright reddish-orange forewings.	Larva	Chemical: Spray during late June or early July when moths are emerging from pupal stage. Second treatment may be necessary just before egg hatch. Cultural: Cut and destroy infected shoots if infestation is new.
Pine Needle Scale	Sucking	Pines	Needles	Needles turn yellow then brown before dropping off. Lower branches may die.	White, waxy covering over insect	"crawler" and egg	Chemical: Appropriate sprays to kill eggs during dormant season or "crawlers" in spring.
Pine Sawflies	Chewing (foliage)	Pines	Needles	Caterpillar-like larvae feeding in groups on one branch of the tree at a time.	Occur in groups, resemble caterpillars but with 3 pairs of thoracic legs and 8 pairs of abdominal legs.	Larva	Chemical: Spray when colonies are noticed in the spring.
Spruce Gall Aphids	Sucking	Spruce, especially Norway, white and Cooley	Bases of expanding buds	Cone-like gall at base of new growth.	Light green with waxy "threads".	Nymph	Chemical: Appropriate sprays during dormant or early spring season.
White Pine Weevil	Chewing (burrowing)	Pines, Norway spruce	Terminal shoots (leaders)	Terminal shoot dead or dying; burrows through interior; frass and larvae or pupae present during summer.	Larva legless, creamy white in color, with small light brown head. Adult has a head extension in the form of a snout.	Adult	Chemical: Residual spray applied to leaders in early spring (April and May). Cultural: Remove and destroy infested leaders.

Some Diseases of Christmas Trees

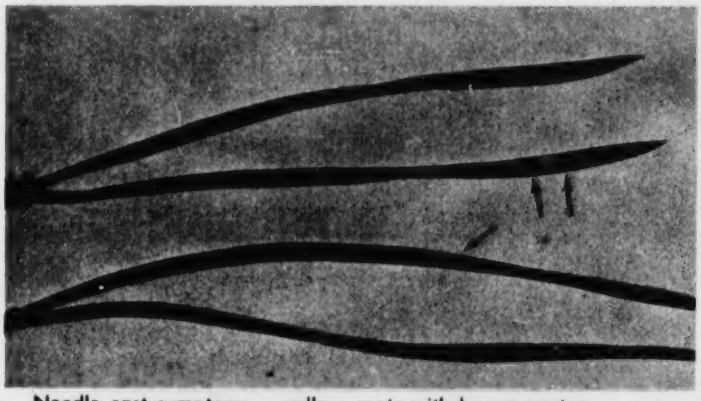
Most diseases of conifers are not imporant factors in Christmas tree culture, or cannot be economically or effectively treated if one is unfortunate enough to discover them in his plantation. It is suggested that frequent inspections be made and that diseased trees be rogued out as soon as discovered. The effects of two diseases -- Lophodermium needlecast of pine and Rhabdocline needlecast of Douglas fir -- can be suppressed through choice of proper sites, for planting, cultural practices and, for Lophodermium, with chemical applications.

Lophodermium Needlecast of Pines

Several kinds of plant pathogenic fungi cause death and premature casting of pine needles. One of these pathogens, a species of Lophodermium, causes significant damage in New York State Christmas tree plantations. Short-needle varieties of Scots pine, especially the Spanish and French-green types, are the most susceptible.



Black elliptical fruit bodies of *Lophodermium* on dead needles



Needle cast symptoms — yellow spots with brown centers

Symptoms

Prominent symptoms appear in spring when 1-year-old needles die and turn straw colored. In spring and early summer the dead needles fall from the twigs. If infection is severe, nearly all 1-year-old needles may be cast. With repeated severe infection, trees become stunted. Within only a few years, the fungus can spread from a single infected tree to nearly all trees in a plantation. Many individual trees seem naturally resistant; they remain green while adjacent trees become heavily infected.

Disease Cycle

Infection occurs once annually in late summer and early autumn. At that time microscopic spores of the fungus are produced in tiny, black, elliptical fruit bodies in dead needles, either lodged among branches of the tree or, usually, lying on the ground. In wet weather the spores are ejected into the air. Those landing on current-season pine needles germinate, and the fungus grows into the needles. The first symptoms are inconspicuous yellow spots. These enlarge and intensify during the autumn and winter, developing brown centers and then coalescing. Infection is usually most severe on the lower branches because they are close to the source of spores, and moist conditions favorable for infection occur more frequently and last longer close to the ground.

Practices That Suppress Disease

Plant Christmas trees on slopes where possible. Space trees and control weeds for good air circulation. Avoid susceptible varieties of Scots pine; if in doubt, use long needle varieties. Trim off and destroy lowest branches to promote air circulation. Spray as recommended with appropriate fungicide.

Rhabdocline Needlecast of Douglas-fir

Fungi in the genus Rhabdocline cause purple-brown spotting and premature casting of needles of Douglas-fir in Christmas tree plantations and occasionally in nurseries. The disease does not often occur on ornamental Douglas-firs in landscapes.

Symptoms and Disease Cycle

Beginning in autumn and winter, small purple-brown spots develop on green 1-year-old needles. When numerous the spots coalesce. The base of each infected needle stays green. From late winter into June, infected needles fall. Tiny blisters less than half the width of the needle develop in May on the lower surfaces of brown spots on infected

needles still on the tree. The blisters, the same color as the spots, are sources of spores that are carried by air currents to developing foliage. The spores germinate and cause new infections in May, but no new symptoms show until the purple spots begin to develop again in autumn. In summer the only symptom may be absence of needles from 1-year-old twigs. Repeated severe infection will make a Douglas-fir of little or no value as a Christmas tree.

Conditions That Suppress Disease

Rhabdocline needlecast is favored by moist conditions and poor air circulation around low branches. Plantations on slopes and where weeds are controlled are least likely to be seriously damaged. The pathogen can mature and produce spores only in needles still attached to the twigs. Thus, by early detection (in March and early April) followed by rogueing severely damaged trees and pruning the low infected branches of other trees, the disease can effectively be suppressed.

Summary - Some Diseases in Christmas Tree Plantations

Name of Disease	Type of Injury	Plant Attacked	Plant Parts Attacked	Infectious or Damaging Stage	Diagnosis	Control Measures
Lophodermium Needlecast of Pine	Dead or discolored needles	Pines	Needles (disease can defoliate and kill tree)	Fungus	Dead or discolored needles	Chemical: Spray monthly during summer. Cultural: Destroy diseased parts (if practicable). Plant resistant varieties.
Rhabdocline Needlecast of Douglas-fir	Dead or spotted needles	Douglas-fir	Needles (disease can defoliate and kill tree)	Fungus	Dead or spotted needles, green at base until premature casting.	Cultural: Rogue out diseased plants or trees (if in a plantation). Plant on slopes, control weeds.

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Some Weeds, Shrubs and Tree Pests in Christmas Trees

Many different weeds, shrubs and trees become pests in Christmas tree plantations. The problem is somewhat different than in other agricultural crops since the applicator must deal with diverse plants ranging from succulent weeds to trees and on terrain that is usually difficult for machinery. Much of the unwanted vegetation is mature and is harder and more expensive to kill than the seedlings in cultivated crops. Some weed and woody plants that are pests in Christmas tree plantations are listed. A brief description and a picture of the weed is given on the pages noted.

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Poison Ivy	212
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The Summary -- Some Weeds, Shrubs and Tree Pests in Christmas Trees immediately following will give you quick information about the pests listed above.

Summary - Some Weeds, Shrubs and Tree Pests in Christmas Trees

Weed, Shrub or Woody Species	Classification	Reproduction	Time and/or Stage of Control	Control Measures
Bindweed	Perennial broadleaf	Seeds and creeping roots	Spring or summer	Chemical: Postemergence Cultural: Mowing
Brambles	Perennial shrub	Seeds and underground runners	Spring or mid-summer	Chemical: Herbicides applied with mist blower or knapsack sprayer. Cultural: Mowing to some degree.
Goldenrod	Perennial broadleaf	Seeds and creeping rhizomes	Spring or summer; germinating seedlings	Chemical: Preplant or postemergence Cultural: Mowing
Hardhack	Perennial shrub	Seeds	Mid-summer or anytime throughout season	Chemical: Mid-summer herbicide applications with mist blower or knapsack sprayer. Cultural: Remove by cutting.
Miscellaneous Hardwoods (Ash, Maple, Oak, Poplar)	Perennial trees	Seeds; roots may spread and sprout from some trees	Anytime throughout season; seedlings stage easiest to control.	Chemical: Foliar or basal applications of herbicides, injection treatments. Cultural: Mowing.
Poison Ivy	Woody perennial	Seeds and creeping rootstocks	Mid-spring or fall when leaves fully expanded	Chemical: Selective-foliar contact or translocated herbicide.
Sumac	Perennial shrub (small tree-like)	Seeds and rootstocks	Mid-summer	Chemical: Mid-summer herbicide applications with mist blower or knapsack sprayer. Cultural: Remove by cutting.

VIII SOME COMMON WEEDS OF AGRICULTURAL CROPS

Barnyardgrass (Watergrass)

Barnyardgrass is a summer annual which reproduces by seed only. It has a fibrous and rather shallow root system. Stems are from one to four feet tall, thick, course, mostly erect, smooth and usually branched at the base. Leaves are from 3/8 to 5/8 inches wide, smooth and light green. The seed head is bearded, green or purplish in color and bears several compact side branches.

Barnyardgrass is widespread throughout the United States and most troublesome on rich moist soil. In the Northeast the pest has flourished with increasing use of irrigation. It is particularly severe in long season crops such as potatoes where cultivation is limited to the early part of the growing period. It reduces yields of many vegetables in proportion to its density and greatly increases difficulty of harvesting.

Barnyardgrass is controlled by frequent cultivation; mow or kill escapees before seed formation. Black plastic is valuable in crops such as cucumbers and melons. Several effective herbicides are available for use in certain crops.

Bindweed (Field)

A perennial herb, field bindweed reproduces by seeds and creeping rootstocks. The root system is extensive and may go down 20 to 30 feet. Stems

are slender, 2 to 7 feet long, and usually spread over the soil surface in a twining manner. Leaves are alternate, simple and are shaped somewhat like an arrowhead with spreading basal lobes. The flowers are white or pink, funnel-shaped, about an inch across and are borne singly in the leaf axils.

Field bindweed can be found in all uncultivated areas and may persist in most cropping systems. Control measures involve the use of herbicides in conjunction with repeated tillage operations.

Brambles

Brambles such as blackberry and raspberry are perennials, somewhat shrubby with semi-woody stems (canes) that are trailing or upright and arching and frequently rooting at the tips. They usually have thorns, prickles or stiff hairs. The canes are of two types--those that grow the first year and only vegetate (rarely flowering and fruiting) and these same canes bearing flowers and fruits the second year. The leaves are compound with 3 or 5 lobed leaflets. There are few to many flowers

in a cluster with petals usually white, rarely pink or pinkish. The fruits are numerous, small and dark purple to red, yellow or white.

There are various species varying from backberries to dewberries and raspberries, forming thickets and bramble patches. They are found in dry places from lowlands to hills and mountains, open woodlands, roadsides, thickets, fence rows and clearings. They may be bothersome in Christmas tree plantations and orchards and are best controlled by chemicals, although mowing will help.

Chickweed (Common)

Common chickweed is a cool season annual, weakly tufted, that reproduces by seeds and creeping stems that root at the nodes. The root system is fibrous and shallow. The stems are much branched, trailing and matted, forming a low spreading plant 4 to 12 inches high. The leaves are small, opposite, simple, smooth and pointed at the end. The flowers are small and white with deeply notched petals. Chickweed may flower throughout the year.

Chickweed is especially bad in gardens, alfalfa, strawberry beds and nurseries. Chemical control is appropriate.

Crabgrass (Large)

Large crabgrass is one of the summer annuals. It reproduces by seed. The stems are stout, smooth and may be 3 feet long. When the stems lie on

the soil surface they form roots at the joints. The flowering shoots grow upright. Leaf blades are 1/4 to 1/3 inch wide and are somewhat hairy. That part of the leaf that surrounds the stem has long dense hairs. The seed head has 3 to 13 finger-like segments at the top of the flowering shoots.

This weed is found in lawns, gardens, and fields. Although it germinates late when the soil is quite warm, it is a serious weed of field crops since it grows well under hot, dry conditions. Control measures involve the use of herbicides and cultivation.

Dandelion

This weed is a perennial that propagates by seed and by shoots from roots. Wherever man has cultivated the soil, dandelion has established itself. The root is large, thick, fleshy growing to a length of 20 or more inches. Any piece of root is capable of forming a new plant. The leaves are basal (form a rosette of leaves growing close to the soil level). They vary from 3-13

inches long, are lance-shaped, deeply and irregularly lobed and toothed. The divisions usually point toward the base. The flowers are large, deep golden yellow. Young dandelion plants are an excellent source of early spring salad greens and potherbs.

They are found wherever there is soil. They are a nuisance in alfalfa. Their flowers attract bees that may be killed when alfalfa is sprayed for other insect pests. Chemical control is the only practical control measure.

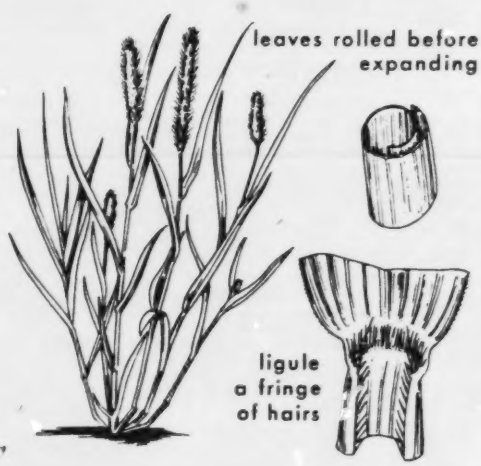
Fall Panicum

Fall panicum is an annual grass with fibrous roots that reproduces by seeds. The stems are erect or spreading, bent at the joints at the base of the plant. The leaves are narrow and lance shaped. The mature seed stalk (panicle) is shaped like a Christmas tree.

Fall panicum is found in gardens, cultivated fields, waste places and low, moist areas. It is often common in corn and soybean fields in the fall.

Both cultivation and chemical control is used to suppress fall panicum.

Foxtail (Green, Yellow)



Foxtail is an annual grass that multiplies by seed. It varies from 1-5 feet in height. The leaf blades are 3-6 inches long, flat, smooth and seem to have a spiral twist. Large white hairs are found on the upper side near the base (sheaf) of the leaf. Spikes (seed)

are 2-4 inches long. Yellow-barbed bristles give the head a yellow sheen.

A serious weed; found in cultivated crops, pastures, meadows, and roadsides. Both cultivation and chemical treatments are used for control.

Galinsoga

Galinsoga is an annual herb reproducing by seeds, with stems erect or spreading, much branched, slender, about 2 feet tall, hairless or with a few fine, soft hairs. Leaves are opposite, egg-shaped and pointed at the tip and about 2 inches long. Flower heads are small, numerous, scattered at the ends of branches. The ray flowers are very small, white, 4-5 in number, surrounding the small yellow disk flowers.

Galinsoga is found throughout the United States except along the Northern border and along the Central Atlantic coast. It is associated with weedy gardens, dooryards, lowland fields and waste places, especially in damp areas with rich soil. It germinates throughout the summer and can be a serious pest in cultivated crops. Plants that are pulled and left on the soil surface reroot easily.

Both tillage and cultivation are useful in its control.

Goldenrod

Goldenrod is a perennial that multiplies by seed and rootstocks. There are several species occuring in New York; Canada and Gray Goldenrod are the most common. Plants vary in height up to 5 feet and seldom branch. The leaves are narrow and lance-shaped. Flowers are a brilliant golden yellow to dull yellow.

Goldenrod is seldom a pest in cultivated fields. It is commonly found in open fields, roadsides and pastures and is a pest of Christmas tree plantations.

Goldenrod can be controlled with herbicides or by mowing.

Hardhack

Hardhack is an erect perennial shrub usually 3-4 feet tall. Its leaves are alternate simple, toothed, 1-3 inches long, oblong, ovate or elliptical; unequal, coarse teeth present in the upper half of the leaf at least. Flowers in July-September are numerous and are deep rose, rose-purple or rarely white; 4-6 inches long and dense. The fruit is small, dry and felted and the twigs are rusty-wooly.

Hardhack can be controlled by foliar sprays of herbicides or by cutting.

Horsenettle

Horsenettle is a prickly, perennial broadleaf which reproduces by seeds and by creeping underground rhizomes. The stem may be simple or branched, 1-4 feet tall, hairy with star-shaped hairs; slender prickles that are straw-shaped. The leaves are alternate and green with yellow prickles on petioles, midribs and veins. The flowers are about 1 inch across, bluish or white and the fruit a yellow, juicy berry.

Horsenettle is a troublesome weed in sandy areas, cultivated fields, waste places and gardens. It is difficult to control and in most cases requires the use of herbicides.

Lambsquarters

Lambsquarters is an annual broadleaf reproducing by seeds. The stems are erect, angular or ridged, hairless, branched above and 2-4 feet tall. They are often striped with pink or purple. The leaves are simple, 1-4 inches long, the lower ones goosefoot-shaped but those near the top lance-shaped. The lower surfaces of the leaves are greyish green or silvery. Flowers are very small, greenish and in irregular clusters at the ends of branches. The seeds are black, shiny and lens-shaped.

This weed is very common throughout the United States, present in essentially all cultivated soils. It competes with all crops for light, nutrients, and water.

It is controlled by frequent shallow cultivation, especially early in the season. Black plastic mulch is valuable in some vegetable crops. Reasonably effective herbicides are available for use in some vegetable crops and in corn, etc.

Miscellaneous Hardwoods

White Oak

Sugar Maple

White Ash

Poplar

Many hardwoods will volunteer throughout Christmas tree plantations and in pastures. It may be well to leave selected specimens for food and shelter for wildlife, particularly if the area is not to be replanted. It is easy to control

seedling or small trees by periodic mowing or cutting, or by foliar or basal applications (up to 5 or 6 inches) of herbicides. Larger trees can be killed by girdling, injection or "frilling". The larger the tree is, the more difficult it is to kill and dispose of.

Mustard (Wild)

Wild mustard is an annual or winter annual weed which reproduces by seeds. The stems are erect, branched near the top and have a few bristly hairs. Lower leaves are irregularly lobed, toothed and have bristly hairs while the upper leaves are somewhat smaller, may or may not be lobed and may or may not have hairs. Yellow flowers are found in clusters at the ends of the branches.

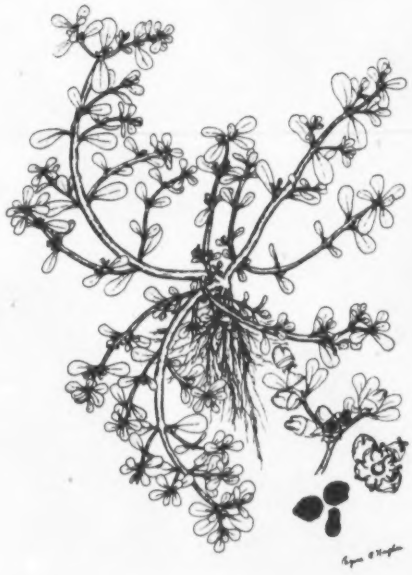
This weed is found commonly in small grain fields and occasionally in other cultivated crops. Herbicides are the main method of control but cultivation can be effective in row-crop situations.

Poison Ivy

Poison Ivy is a perennial that multiplies by seeds and creeping rootstocks. The plant may be upright, trailing, or climbing. The leaves consist of 3 oviate leaflets, 1 1/2 to 4 inches long, shiny smooth and hairy underneath. The leaves are red or reddish-yellow in the fall. The flowers are small, green, in a head 1-3 inches long. The fruit (berries) is a cluster of greenish white waxy berries.

Poison ivy is usually found in woods and damp fields. It is a pest of Christmas tree plantations and orchards. Do not handle. Poison ivy produces a severe rash upon people allergic to it. Control chemically, making sure that the herbicide is registered for such use if used around food crops.

Purslane (Pussley)



Purslane is an annual that multiplies by seed. Few vegetable farms are without it. Plants are prostrate (lying flat on ground) 4-12 inches or more in length, branching from all sides of the central root. The leaves are small; wedge-shaped to egg-shaped to oblong, 1/2 to 2 inches long, very thick and fleshy. Both stems and leaves have a reddish tinge. The flowers are yellow 1/2 inch in diameter and open only in bright sunshine.

Purslane or pussley is a troublesome weed in all cultivated soils. Tolerating dry conditions, each plant produces thousands of tiny seeds. If the plant is pulled and left on the ground, it easily takes root again.

It can be controlled by frequent cultivation before seeds are developed and by removing all plants from the garden after they have been cultivated. Black plastic also helps. Very effective herbicides are available.

Quackgrass (Witchgrass, Couchgrass)

This grass is a perennial that multiplies by seeds and yellowish rhizomes (runners, underground stems, rootstocks). The plant is 20-40 inches

tall with leaves 3-12 inches long and 1/8 to 3/4 of an inch wide. They are sharply pointed, hairy above and smooth below. The flower spikes are 4-8 inches long and resemble a slender head of wheat. It is the most obnoxious weed in cultivated soils. Once it becomes established it is very hard to eradicate by cultural means.

Quackgrass is found in open waste areas, pastures and most cultivated fields. It requires special control measures involving a combination of chemical and mechanical control methods.

Ragweed (Common)

Common ragweed is a shallow-rooted annual weed which reproduces by seeds. The stems are rough, hairy, erect, branching and 1 to 4 feet tall. Leaves are mostly alternate, nearly smooth, but deeply cut into many lobes. Flowers are of two kinds. Male flowers are borne in small inverted clusters at the tips of branches while the seed-producing flowers are found at the bases of leaves and in forks of upper branches.

Common ragweed is found in pastures, wastelands, roadsides, and cultivated lands. Effective control programs involve the use of herbicides and cultivation.

Redroot Pigweed

Redroot pigweed, a summer annual reproducing by seeds, has a shallow, red taproot. The stems are erect, very rough, branch freely if not crowded and grow up to 6 feet high or more. The leaves are somewhat egg-shaped and dull green in color. Redroot pigweed flowers are green, small and clustered together in the upper leaf axils and at the tips of branches. Each flower is surrounded by 3 spiny bracts.

It is widespread throughout the United States and one of the commonest weeds in the Northeast. Practically all our soils are infested with this seed which is known to be able to survive for at least 30 years. Dense stands result in severe shading of crops and compete for available moisture and nutrients.

It is controlled by frequent shallow cultivation; use of black plastic in vine crops, peppers, tomatoes, etc. Use of sod crops in a rotation is of some value. Reasonably effective herbicides are available for use in some vegetable crops and it is easily controlled with herbicides in corn.

Shepherdspurse

Shepherdspurse is an annual or winter annual herb which reproduces by seed and has a branched taproot. Stems are erect branched, 1 to 1 1/2 feet tall and covered with gray hairs. Leaves in rosettes at the base are coarsely lobed and 2 to 4 inches long. Leaves higher on the stem are arrow-shaped and considerably smaller than the basal leaves. The flowers are

small, white, have 4 petals each and are borne in elongated groups at the ends of the branches.

Shepherdspurse is found in practically all crops as well as in noncultivated areas. Herbicides and cultivation are the main methods of control.

Sumac

There are seveal species of sumac, but staghorn and smooth are probably the most common in New York. The leaves are alternate, pinnately compound to 24 inches long with 11-31 leaflets. The stalk can be either hairless or very hairy, often reddish on top. The leaflets are 2-5 inches--oblong; with the margin sharply toothed and pale-white beneath. The tree flowers in May - July, forming greenish, hairy or minutely hairy clusters. The fruit clusters are large, hairy, upright and conical.

Sumac usually grows as a shrub in colonies. It rarely becomes treelike. It can be controlled by cutting and is susceptible to several herbicides.

Velvetleaf

Velvetleaf is an annual herb which grows from 6 to 8 feet tall and has a strongly developed taproot. The stout stems are covered with short velvety hairs. Leaves are alternate large, heart-shaped and have a soft, velvety surface. The flowers are about 3/4 inch in diameter, yellow and occur on the upper part of the stem. Seed pods are cup-shaped, about 1 inch in diameter and have a ring of prickles around the upper edge.

This weed is found in waste places, gardens, and cultivated fields, especially corn and soybean fields. Control should involve the use of cultivation and herbicides.

Yellow Nutsedge

Yellow nutsedge is a perennial weed which reproduces by seed and tubers (nuts). The roots are fibrous and often bear nut-like tubers at the tips. Stems are erect, yellow-green and are triangular (3-sided). The shape of the stem is useful in distinguishing yellow nutsedge from grasses which have either round or flat stems. There are 3 rows of narrow, grass-like leaves arising from the base of the plant. Flowers are small and yellow or yellow-brown.

This weed is a serious pest on low, damp soils but is often a problem in cultivated fields. It is difficult to control and most successful control programs involve the use of herbicides.

Yellow Rocket (Winter Cress)

Yellow rocket is a short-lived perennial reproducing by seeds and sometimes by new shoots from the old crown. It has a taproot and numerous erect stems growing 1-2 feet tall. The stems are branched near the top smooth, angular or rigid. Leaves are divided (rarely simple) and the basal leaves have a large terminal lobe, forming a rosette. The flowers ar spike-like at the end of each branch and are bright lemon-yellow.

Yellow rocket can be found along meadows and roadsides; rich alluvial soils, and in small grains, clover and alfalfa fields. Seeds can live several years in the soil.

Chemical control is usually necessary.

ACKNOWLEDGEMENTS

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Those making contributions are as follows:

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J. L. Brann	Fruit Insects
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J. E. Dewey	Chemicals-Pesticides Program
R. R. Hahn	Field and Forage Weeds
A. A. Muka	Vegetable, Field and Forage Insects
R. F. Pendleton	Chemicals-Pesticides Program
A. F. Sherf	Vegetable Diseases
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W. G. Smith	Chemicals-Pesticides Program

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Materials from numerous others than those listed above have been utilized without citation but with appreciation.

POISONING HAZARD TO HONEY BEES OF INSECTICIDES AND MITICIDES ON BLOOMING CROPS

Use Rating	Residual Toxicity	Material
Hazardous to honey bees at any time	High, 1 day to 2 weeks	arsenicals, Azodrin, Baygon, Bidrin, carbaryl (Sevin), carbofuran (Furadan), chlorpyrifos (Dursban), Dasanit, dichlorvos (Vapona), dimethoate (Cygon), dinoseb, endothall, EPN, fenthion (Baytex), Guthion, heptachlor, Imidan, lindane and benzene hexachloride, malathion D, malathion ULV, Matacil, Methyl Parathion, Methyl Trithion, naled (Dibrom) D, parathion, Phosdrin, phosphamidon.
Not hazardous if applied in either evening or early morning when honey bees are not foraging, except during periods of high temperature in these times	Moderate, 3 hours to 1 day	Abate, carbophenothion (Trithion), Carzol, chlordane, demeton (Systox), dioxathion (Delnav), Di-Syston EC, endosulfan (Thiodan), endrin, ethion, heptachlor G, malathion EC, methomyl (Lannate SP), methoxychlor, Meta-Systox-R, Morocide, naled (Dibrom) EC, VC-13 Nemacide, Orthene, Perthane, phorate (Thimet) EC, G, Phostex, Phosvel, TEPP, Thanite, Torak, toxaphene, trichlorfon (Dylox), Zolone.
Not hazardous to bees at any time	Low, 1 hour to 1 day	Acaraben (chlorobenzilate), Acaralate (chloropropylate), allethrin, Baygon G, carbaryl (Sevin) G, carbofuran Furadan) G, Dasanit G, Dikar, Di-Syston G, Galecron and Fundal SP, Karathane, Kelthane, lime-sulfur, malathion G, Morestan, oil sprays (Superior), propargite (Omite), Pentac, Plictran, pyrethrum, rotenone, sulfur, Temik G, tetradifon (Tedion). Most herbicides and fungicides.

Abbreviations: EC - emulsifiable concentrate; D - dust; ULV - ultra low volume; WP - wettable powder; G - granular; SP - soluble powder